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(54) SEMICONDUCTOR MODULE AND POWER CONVERTER

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a reliable semiconductor module which has high capability for cooling and is free of the risk of insulation breakages due to thermal stress during manufacture or operation it, and to provide a power converter using it.
SOLUTION: Conductor members 103, having channels 106 in the inside, are connected to a base plate 101 via a resin insulating layer 102, and a power semiconductor elements 104 are soldered respectively to these members 103, as the conductors of a circuit pattern. Then, the channels 106 of the respective members 103 are connected by an insulated piping 105 to make cool water flow through it. Since only soldered layers 107 exist between the elements 104 and the members 103, cooling capability is high and since there is no risk of insulation breakages to occur due to thermal stress during the manufacture or the operation, a reliable power semiconductor module is obtained.

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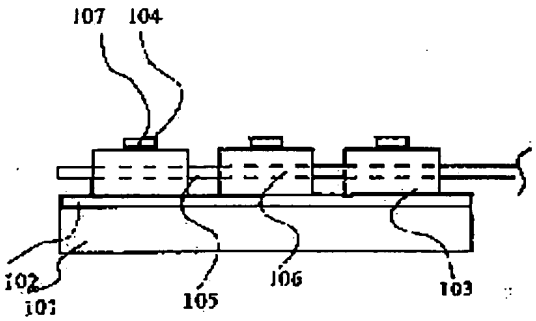

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* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]
[Claim 1] In the semiconductor module of the method which carries out soldering junction of the semiconductor device on the surface of a conductor the base -- the object for circuit patterns formed through the insulating layer on the surface of the member -- a conductor -- having -- this object for circuit patterns -- the aforementioned object for a circuit pattern -- the portion of a conductor to which the aforementioned semiconductor device is joined at least the conductor which the hole used as the circulation way of a fluid has penetrated inside -- the semiconductor module with which it forms by the member and thermolysis of the aforementioned semiconductor device is characterized by constituting so that it may be given with the fluid by which conduction is carried out to the aforementioned circulation way
[Claim 2] the conductor which has the aforementioned circulation way in invention according to claim 1 -- a member -- two or more pieces -- these conductors -- the semiconductor module characterized by arranging them about at least two in a member at the aforementioned base member as the outlet and entrance of those circulation ways are located on the same straight line
[Claim 3] It is the semiconductor module which equips the circulation system which consists of heat-exchange equipment which cools the fluid by which conduction is carried out to the aforementioned circulation way in invention according to claim 1, and the aforementioned circulation system with the electrical circuit which drives the pump which pours a refrigerant, and the aforementioned pump, and is characterized by installing the aforementioned electrical circuit in the aforementioned base member.
[Claim 4] The semiconductor module which the aforementioned heat-exchange equipment is an air-blast-quenching formula, and is characterized by the thing [having constituted so that the aforementioned base member might be cooled more in the style of cooling] in invention according to claim 3.
[Claim 5] The semiconductor module characterized by constituting so that conduction of the fluid with which the aforementioned base member has a circulation way inside, and was cooled by this circulation way with the aforementioned heat-exchange equipment in invention according to claim 3 may be carried out.
[Claim 6] the conductor which has the aforementioned circulation way in invention according to claim 1 -- the semiconductor module characterized by being constituted so that conduction of the aforementioned fluid to the circulation way concerned of a member may be performed through insulating piping and the melting point of this insulating piping may become higher than the melting point of the brazing filler metal used for the aforementioned soldering junction
[Claim 7] The semiconductor module characterized by being the refrigerant with which the aforementioned fluid branched from the air-conditioner equipment currently installed separately in invention according to claim 1.
[Claim 8] The power converter characterized by using a semiconductor module according to claim 1 to 7 as a switching element of a main circuit.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention -- the base -- the object for circuit patterns formed through the insulating layer on the surface of the member -- a conductor -- a member -- having -- this object for circuit patterns -- a conductor -- the semiconductor module of the method which carries out soldering junction of the semiconductor chip on the surface of a member is started, especially it is related with the suitable power semiconductor module for the switching element for power conversion, and the power converter using it [0002]
[Description of the Prior Art] The power semiconductor module which contained the switching element, and IPM (Inteligent Power Module) which built the control circuit in this are large in the field as which high-reliability, such as an automobile and a rail car, is required in recent years, and a use spreads, consequently especially the improvement in reliability is demanded.
[0003] And since switching elements, such as IGBT (insulated-gate bipolar transistor), are also large-capacity-ized and the calorific value of a semiconductor device (semiconductor chip) increases in connection with this at this time, improvement in refrigeration capacity is required strongly. Moreover, although utilization of a hybrid car is progressing in recent years, as for a power semiconductor device, in the case of the hybrid car of the method it runs mainly by the motor (motor), only a short time generates heat greatly for every start here at the time of start.
[0004] Therefore, for such a use, although the maximum of the virtual junction temperature of a power semiconductor device is low, the exothermic-change width of face of a power semiconductor device becomes large, the stress change by thermal expansion and the thermal contraction and the so-called heat rocking also become large, and the number of times also increases. And since especially this heat rocking gives a thermal fatigue to the brazing joint by solder etc., effective cooling is needed for highly reliable grant and highly reliable maintenance.
[0005] By the way, in such a power semiconductor module and IPM, it is common to usually consist of the base which consists of a metal of high temperature conductivity etc., an insulating substrate which consists of material of high temperature conductive and high electric insulation, and a conductive layer in which the circuit pattern was formed in consideration of the numerousness of the calorific value of the power semiconductor device carried, and it is usually at this time that the material of an insulating substrate is chosen according to the calorific value of loading parts.
[0006] And with the product of large capacity [capacity / inside / with big calorific value], as an insulating substrate, although it is expensive, ceramics, such as alumina ceramics with large thermal conductivity and alumimium nitride ceramics, are mainly used. Here, an example of the power semiconductor module by the conventional technology is shown in drawing 23 and drawing 24 .
[0007] This module forms like illustration the power semiconductor device 104 by which soldering junction was carried out on circuit pattern 2102a which has formed in lamination and this ceramic board 2101 the ceramic board 2101 which turns into an insulating substrate in one field (drawing upper field) of the base boards 101, such as copper. At this time, soldering junction

of the ceramic board 2101 is carried out at the base board 101 using copper pattern 2102b on the back.
[0008] And after connection by the metal wire 304 was made to this circuit pattern 2102a and wiring to external end-connection child 302a for power and external end-connection child 302b for signals is performed further, it is dedicated in a case 303, and it is closed with a resin 301. In addition, resins are synthetic resin and the so-called plastics here.
[0009] next -- although the base board 101 makes grease 2105 intervene and is attached in a cooling member -- here -- drawing 23 -- cooling of a water cooling type -- air-cooled cooling whose drawing 24 has a fin by the case where it attaches in a member 2104 -- it is the case where it attaches in a member 2201, and all are fixed to a cooling member by the mounting bolt 2103 at this time
[0010] By the way, since the various material from which coefficient of linear expansion differs is used, as for a power semiconductor module, it is common that curvature is in the base board 101. Here, the directions of this curvature may be the both sides of the direction of a convex where the direction of concave where the center of the plane of composition to the cooling member of the base board 101 has become depressed, and the center of a plane of composition have swollen by parts and the manufacturing process.
[0011] the case where curvature is the direction of concave -- the base and cooling -- a member -- since the thickness of the grease 2105 which is in between increases -- the base and cooling -- a member -- since the contact thermal resistance of a between becomes large, refrigeration capacity declines, the temperature rise of the power semiconductor device 104 is not stopped at the time of operation, there is also a possibility that a performance may fall and break and heat rocking also becomes large, the life of the joint by the soldered joint layer 107 etc. will fall
[0012] On the other hand, when curvature is the direction of a convex and the bolt 2103 for attachment is bound tight, the big bending moment will appear in the ceramic substrate 2101, and a crack will often arise. Here, since, as for the ceramic substrate 2101 which the crack produced, the insulating tolerance dose will be lost, such a semiconductor module will become use impotentia.
[0013] Thus, although there is especially no problem in refrigeration capacity, the power semiconductor module using the ceramic substrate 2101 which is easy to break easily, therefore is shown in drawing 23 and drawing 24 although the ceramic substrate 2101 is a high insulation in high temperature conduction has the danger of producing the fatal defect of dielectric breakdown by the crack of the ceramic substrate 2101, and careful cautions are required for it on the occasion of anchoring.
[0014] On the other hand, by the power semiconductor module of small capacity with comparatively little calorific value, as an insulating substrate, although thermal conductivity is not so high, the quite cheap insulating layer made of a resin is used. Drawing 25 is an example of the small capacity power semiconductor module by the conventional technology, and the resin insulating layer 102 is used instead of the insulating substrate in this case.
[0015] And the conductive layer 306 used as a circuit pattern is formed in this resin insulating layer 102, the power semiconductor device 104 is joined by solder on this conductive layer 306, and other composition is the same as the case of drawing 24 . By the way, when this resin insulating layer 102 is used, curvature as well as the case where the ceramic substrate 2101 is used arises.
[0016] Here, when curvature is the direction of concave, a contact thermal resistance increases similarly and refrigeration capacity declines. On the other hand, when curvature is the direction of a convex, since modulus of direct elasticity is small and stretch is large as compared with the ceramic substrate 2101, there is no possibility of 102 resin insulating layer that it may be divided.

[0017] As mentioned above, the resin insulating layer 102 has a problem in refrigeration capacity, although modulus of direct elasticity is small, thermal conductivity is small although stretch is also large, therefore there is no possibility that, as for the power semiconductor module using the resin electric insulating plate 102 of this drawing 25 , an insulating substrate may break in

the case of anchoring.
[0018] By the way, grease 2105 is used by each by the above semiconductor module. Here, since this grease 2105 is silicon resin and the composite material of SERAMMIKU powder, its thermal conductivity is not so high.
[0019] although several steps are excellent rather than there is nothing, since [for this reason,] there is this grease 2105 -- the base and cooling -- a member -- the thermal resistance of a between -- the power semiconductor device 104 and cooling -- if about several percent of the thermal resistance between members will be occupied, therefore a contact thermal resistance in the meantime can be reduced, it can contribute to improvement in refrigeration capacity greatly
[0020] Then, there is a power semiconductor module shown in drawing 26 as the fall of the refrigeration capacity by this contact thermal resistance, and a cure of dielectric breakdown by the crack of an insulating substrate. the module shown in this drawing 26 -- the ceramic substrate 2101 -- direct and brazing -- cooling -- the base board 101 in the semiconductor module which joined to the member 2201, therefore was shown in drawing 24 , and cooling -- the joint between members 2201 does not exist from the beginning
[0021] Therefore, since there is also no layer of the grease by which it should be placed between joints, of course in the case of this module and a contact thermal resistance does not exist in essence, refrigeration capacity improves by leaps and bounds. Moreover, since there is also no anchoring by thread fastening of the base board 101 as a result, there are also few possibilities that the crack by bolting may occur.
[0022] and this time -- cooling -- fear of the crack which the residual stress by the temperature change at the time of junction to the ceramic substrate 2101 and the thermal stress in the time of operation are reduced, consequently is generated in the ceramic substrate 2101 can be suppressed still smaller by constituting a member 2201 from material with small coefficient of linear expansion, such as aluminum-SiC
[0023]
[Problem(s) to be Solved by the Invention] Consideration was not carried out to the point which has a limit in the improvement in refrigeration capacity of a semiconductor device, but the above-mentioned conventional technology had a problem in large-capacity-izing of a semiconductor module, and highly reliable maintenance. First, as described above, the conventional technology shown in drawing 23 or drawing 25 had the problem of the crack of an insulating substrate, and misgiving was in application for the use as which high-reliability is required.
[0024] moreover, such conventional technology needed careful cautions also for anchoring, further, since grease was low-fever conduction, even if it uses this, difficulty stops the contact thermal resistance between a fin and the base small, and the problem was in improvement in refrigeration capacity
[0025] on the other hand, it described above with the conventional technology shown in drawing 26 -- there are few possibilities that the residual stress by the temperature change at the time of ceramic substrate junction and the thermal stress in the time of operation can be reduced, consequently a ceramic substrate may break, by using material with a small coefficient of linear expansion for a cooling member
[0026] However, since it is essentially a weak material and thermal stress also becomes large when the area of a ceramic substrate becomes large by large capacity-ization, ceramics have a possibility that an insulating substrate may break. Moreover, when there is a possibility that a crack may arise in a ceramic substrate when vibration applies to a severe use and a ceramic substrate is used, even if an automobile etc. needs careful cautions for the handling of a power semiconductor module and it faces it maintenance, it is necessary to pay sufficient attention.
[0027] The purpose of this invention is excellent in refrigeration capacity, and is to offer the power converter using the highly reliable power semiconductor module and it with the small danger of dielectric breakdown by the crack of an insulating substrate.
[0028]
[Means for Solving the Problem] In the semiconductor module of the method which carries out soldering junction of the semiconductor device on the surface of a conductor the above-

mentioned purpose -- the base -- the object for circuit patterns formed through the insulating layer on the surface of the member -- a conductor -- having -- this object for circuit patterns -- the aforementioned object for a circuit pattern -- the conductor to which the hole used as the circulation way of a fluid has penetrated the portion of a conductor to which the aforementioned semiconductor device is joined at least inside -- it forms by the member, and it is given with the fluid by which conduction is carried out to the aforementioned circulation way, and thermolysis of the aforementioned semiconductor device makes and is attained
[0029] the conductor which has the aforementioned circulation way at this time -- a member -- two or more pieces -- these conductors -- about at least two in a member The circulation system which the outlet and entrance of those circulation ways become from the heat-exchange equipment which cools the fluid by which may be arranged at the aforementioned base member as is located on the same straight line, and conduction is carried out to the aforementioned circulation way, The aforementioned circulation system is equipped with the electrical circuit which drives the pump which pours a refrigerant, and the aforementioned pump, and the aforementioned electrical circuit may be made to be installed in the aforementioned base member.
[0030] Moreover, at this time, the aforementioned heat-exchange equipment is an air-blast-quenching formula, the aforementioned base member may be made to be cooled more in the style of cooling, or the aforementioned base member has a circulation way inside, and the conduction of the fluid cooled by this circulation way with the aforementioned heat-exchange equipment may be made to be carried out.
[0031] furthermore, the conductor which it has in the aforementioned circulation way -- it may make be the refrigerant with which conduction of the aforementioned fluid to the circulation way concerned of a member was performed through insulating piping, it could constitute so that the melting point of this insulating piping might become higher than the melting point of the brazing filler metal used for the aforementioned soldering junction, and the aforementioned fluid branched from the air-conditioner equipment currently installed separately
[0032] Similarly the above-mentioned purpose is attained by constituting a power converter in one of the above, using the semiconductor module of a publication as a switching element of a main circuit.
[0033]
[Embodiments of the Invention] First, before explaining concretely about the gestalt of operation of this invention, the plan of drawing 1 and the side elevation of drawing 2 explain the fundamental composition of this operation gestalt briefly here. In these drawing 1 and drawing 2 , first, 101 is a base board and the resin insulating layer 102 is formed in one field of this base board 101. 103 [next,] -- a conductor -- the circuit pattern to which it is a member, and it is divided into some portions and a semiconductor device is joined by this like illustration -- a conductor is formed
[0034] and -- each -- a conductor -- through the resin insulating layer 102, a member 103 is arranged on the base board 101, and is joined to the base board 101 by the resin insulating layer 102 -- having -- **** -- these -- each -- a conductor -- each power semiconductor device 104 is joined to the exposed surface of a member 103 by the soldered joint layer 107
[0035] here -- each -- a conductor -- it has predetermined thickness as a member 103 is made from electrical conducting materials, such as copper, and it is expressed to drawing 2 , and the hole which becomes the thickness direction and a right angle with the path of the fluid for cooling to the interior, respectively is formed as a circulation way 106 of a-two round trip
[0036] and these circulation ways 106 are mutually open for free passage with the piping 105 currently made from the insulating material, i.e., insulating piping, -- having -- each -- a conductor -- it passes along the circulation way 106 of a-two round trip of a member 103, and it is made so that a series of fluid channels for cooling may break and it may be formed as a ********** path
[0037] then, the piping 105 -- minding -- each -- a conductor -- if the circulation way 106 of a member 103 is made to carry out conduction of the fluid used as a predetermined coolant, for example, the water of predetermined temperature, -- each -- a conductor -- the circuit pattern

to each power semiconductor device 104 which boils a member 103, respectively and is joined -- while forming a conductor, it will work also as a member which cools each power semiconductor device 104

[0038] here according to the composition of these drawing 1 and drawing 2 -- each -- a conductor -- since it decreases sharply as compared with the case where the soldered joint layer 107 only intervened, and the cooling water in the circulation way 106 and the thermal resistance between the power semiconductor devices 104 were very small for it, and it is placed between them by the conventional insulating substrate since all [the heat transfer path between a member 103 and the power semiconductor device 104 / the insulator], a high cooling performance is obtained easily

[0039] moreover, since piping 105 has been carried out to insulating piping at this time, it is in different potential -- each -- a conductor -- the insulation needed between members 103 obtains easily -- having -- a conductor -- formation of the circuit pattern by the member 103 also becomes easy moreover, this time -- each -- a conductor -- on the base board 101, two or more members 103 are put in order and arranged

[0040] then -- each -- a conductor -- the entrance and outlet of the circulation way 106 of a member 103 are arranged on the same straight line By this, the entrance and outlet of each circulation way 106 can face each other on a straight line, and can make it arrange, connection of piping can be performed easily, and brief piping can be formed.

[0041] by the way -- each -- a conductor -- since the circulation way 106 is formed into it, it is necessary to thicken a member 103 far as compared with the conductor layer in a common circuit pattern here -- this conductor -- if the thickness of a member 103 increases, the thermal stress generated at the time of processing and operation will become large according to the difference of coefficient of linear expansion with the base board 101

[0042] however, the thing for which modulus of direct elasticity is small to the resin insulating layer 102, and stretch applies a large material to it here -- a conductor with big thickness -- even if it joins a member 103 to the base board 101, there is no possibility of inviting the insulating fall by the crack and the crack to the resin insulating layer 102 by thermal stress

[0043] this time -- thermolysis of the power semiconductor device 104 -- a conductor -- since the inside of the circulation way 106 of a member 103 is depended on heat transfer of the flowing cooling water, and the value of heat conduction of the resin insulating layer 102 does not become a problem at all, as described above, the quality of the material from which generating of a crack does not take place can be chosen arbitrarily

[0044] Next, the gestalt of implementation of illustration explains the power semiconductor module by this invention concretely. However, this invention is not restricted to the gestalt of the operation explained below.

[0045] First, drawing 3 , drawing 4 , and drawing 5 are the gestalten of the 1 operation at the time of applying this invention to a power semiconductor module including a three-phase-circuit power circuit, drawing 3 expresses the planar structure and, as for drawing 4 , the A-A cross section of drawing 3 and drawing 5 express the B-B' cross section of drawing 3 here.

[0046] Moreover, drawing 6 is the equal circuit of this three-phase-circuit power circuit, and that of the sign for each terminal area is the same as that of the sign in the terminal of drawing 3 . In addition, this equal circuit is used as an inverter of a three phase circuit.

[0047] the conductor which the power semiconductor module by this operation form forms the resin insulating layer 102 used as an insulating substrate in one field (field of the direction which has turned up in drawing 4) of the base board 101 in these drawings, and has the circulation way 106 on it -- the conductive layer 306 used as a member 103 and other circuit patterns -- joining -- this conductor -- the power semiconductor device 104 is joined to the position on a member 103 by the soldered joint layer 107

[0048] and -- each -- a conductor -- it is mutually open for free passage with insulating piping 105a, and the circulation way 106 of a member 103 is pulled out outside moreover -- each -- a conductor -- on the member 103, another circuit pattern 305 is joined through the insulating layer 401

[0049] furthermore, the power semiconductor device 104 and a conductor -- the conductive

layer 306 is connected to a member 103, the circuit pattern 305, and it by the metal thin line 304, respectively (omitted in drawing 4) Here, the wire of the aluminium alloy about 300-500 micrometerphi is used for these metal thin lines 304.
[0050] moreover, a conductor -- the internal connection terminal 308 and the external end-connection child 302 are suitably formed in the member 103, the circuit pattern 305, and the conductive layer 306, the printed circuit board 307 is connected to the internal connection terminal 308 (the dashed line shows only the appearance of a printed circuit board 307 to drawing 3), and external end-connection child 302b is further prepared in this lint substrate 307 suitably
[0051] here, with this operation form, a case 303 pastes the base board 101 through the resin insulating layer 102 -- **** (the dashed line shows only the appearance of a case to drawing 3) -- using the PPS (polyphenylene sulfide) resin which has thermal resistance as a material of a case 303 at this time -- the power semiconductor device 104 and a conductor -- the junction, simultaneously the case 303 by the solder of a member 103 can be pasted up on the resin insulating layer 102
[0052] and these conductors -- some external end-connection children 302 are closed by a part of member 103, insulating piping 105, a conductive layer 305, the circuit pattern 305, the power semiconductor device 104, the metal thin line 304, the internal wiring 308, and it with the resin 301 with high thermal conductivity, and he is completed as a power semiconductor module
[0053] In order that a closure resin may prevent having a bad influence on a metal thin line or an element at the time of closure, and the time of use, you may make it use comparatively soft material, such as silicon gel, although it is common at this time to use stiff thermosetting resin comparatively, such as an epoxy resin, to the resin 301 for this closure.
[0054] Furthermore, if it explains concretely, the base board 101 is first made from lightweight and cheap aluminum or an aluminium alloy. This is because it is suitable for the aluminum which is cheap and can do it lightweight as compared with copper since this base board 101 has comparatively big volume within a power semiconductor module producing a power semiconductor module.
[0055] On the other hand, when a cooling performance is thought as important, copper with still higher thermal conductivity is used. At this time, the base board 101 is made into the thickness of at least 2mm, and may be made into the thickness of about 30mm so that reduction of the thermal resistance by the breadth of the heat in the interior may fully be obtained. Here, you may prepare the fin further for forced-air cooling, or the water-cooled tube for water cooling in this base board 101.
[0056] Next, since high insulation is required, for this reason, the epoxy resin by which the filler was distributed is used for the resin insulating layer 102 used as an insulating substrate. In addition, thereby, low thermal resistance nature is also given.
[0057] And since a modulus of longitudinal elasticity is small as compared with a ceramic board and stretch is large, the resin insulating layer 102 by the epoxy resin by which this filler was distributed does not have a possibility that it may be divided also with the thermal stress at the time of junction and operation.
[0058] Here, that what is necessary is just to use for a filler what was made from the inorganic compound of high temperature conductivity of for example, oxidization silicon, an aluminum oxide, etc., the thermal resistance of the resin insulating layer 102 can be reduced, so that the content of a filler is increased at this time.
[0059] However, since there is a limitation in the amount of fillers which can be distributed in an epoxy resin, it is good to usually make content of a filler into 75 - 95% of range, and the thermal conductivity of the resin insulating layer 102 serves as the range of 2 - 5 W/mK in this case.
[0060] On the other hand, an option effective in reducing the thermal resistance of the resin insulating layer 102 is making it thin. However, if the resin insulating layer 102 is made thin, although there will be a possibility that may become easy to generate a pinhole etc. in a resin insulating layer, and reliability may fall to it when the part and isolation voltage fall, therefore there will be a limitation in the minimum of the thickness of the resin insulating layer 102 and it will be based also on the isolation voltage demanded, about 50-250 micrometers becomes a

minimum.
[0061] It is better to be thicker than the case of the conventional power semiconductor module here, since relief of the thermal stress at the time of processing and operation is required rather than reduction of thermal resistance about this resin insulating layer in the case of this invention.
[0062] moreover, this resin insulating layer 102 -- a conductor -- the creeping distance which is equivalent also to these circumferences at isolation voltage since a member 103 and a conductive layer 306 are insulated from the base board 101 -- required -- this sake -- an insufficient part -- the front face of the base board 101 -- an insulating layer -- a wrap -- it is necessary to compensate with things
[0063] then -- this operation form -- illustration -- like -- this resin insulating layer 102 -- the conductor of the base board 101 -- it has prepared all over the member 103 side next, a conductor -- as a material of a member 103, when it gives priority to heat conduction, the alloy of copper or aluminum is chosen
[0064] Although there is an advantage that aluminum is lightweight, at this time, since coefficient of linear expansion is large, a problem is in the reliability of the soldered joint layer 107 which joins the power semiconductor device 104, and the use of which high-reliability is required is not turned to. on the other hand -- copper -- aluminum -- comparing -- low thermal-expansion nature and high temperature conductivity -- it is -- therefore, a conductor -- it is suitable for the member 103
[0065] moreover, the power semiconductor device 104 and a conductor -- the case where the reliability of the soldered joint layer 107 which joins a member 103 is taken into consideration -- a conductor -- coefficient of linear expansion chooses material with comparatively high near and thermal conductivity as the silicon which forms the power semiconductor device 104 as a member 103
[0066] although there are molybdenum, an aluminum silicon carbide (aluminum-SiC), copper, composite material of a copper-acid ghost, etc. as a material which corresponds at this time -- this conductor -- since it is necessary to establish the circulation way 106 in a member 103, in consideration of processability, it can be said that copper and the composite material of a copper-acid ghost are the optimal
[0067] the time of this copper and the composite material of a copper-acid ghost being able to change coefficient of linear expansion and thermal conductivity with the ratio of copper and a copper-acid ghost, and the ratio of a copper-acid ghost being 30% here -- coefficient of linear expansion -- 13.5x10-6 / K -- it is -- thermal conductivity -- 240 W/mK -- becoming -- this -- a conductor -- it is suitable for the member 103
[0068] next -- each -- a conductor -- it is made for a member 103 to have the entrance and outlet of the circulation way 106 on a straight line When it is made for an entrance and an outlet to be on a straight line, it can constitute from same parts and there is an advantage of making piping connection easily.
[0069] here -- the operation form of drawing 3 -- one conductor -- a member -- everything but 103a -- the conductor of the same configuration -- although 103bis located in a line and arranged three members, if the entrance and the outlet were located in a line on the straight line like illustration at this time, when the same parts will have been arranged side by side, piping connection of each entrance and outlet is made as it is
[0070] Next, the piping connection method at this time is explained. after making piping connection with the operation form of drawing 3 -- a conductive layer 306 and a conductor -- a member 103 is joined to the resin insulating layer 102, and drawing 9 explains the procedure of the piping connection at this time from drawing 7
[0071] that these drawings indicated piping connection sequence to be -- it is -- the direction of an arrow -- piping 105 and a conductor -- piping is connected by moving a member 103 an assembly efficient here sake -- each -- a conductor -- a member -- it is good it to become requirements that the entrance and outlet of the circulation way 106 in 103b are on a straight line and to provide sufficient space for the opposite side of the piping connection direction, and to make it a piping path become a picture drawn without lifting the brush from the paper like

illustration further
[0072] by the way -- each -- a conductor -- since a member 103 is a conductor which forms a circuit pattern and has become wiring of a part of circuit shown in drawing 6 -- a conductor -- a member -- the case where it becomes the potential from which 103 comrades differ -- it is -- this case -- a conductor -- it is necessary to use insulating piping for connecting the circulation way 106 of a member 103
[0073] With the operation form of drawing 3 , since conductive member 103 differs in potential, respectively, it has piped by insulating piping 105a. however, the conductor which becomes this potential -- a member -- piping of comrades does not need to be insulating piping Here, piping 105b of drawing 3 is not insulating piping.
[0074] Insulating piping 105a is prepared in piping connected to the pump for cooling water flows which is outside on the other hand, and piping linked to the heat exchanger for cooling of the water which carried out the temperature rise by generation of heat of a power semiconductor device, and it is made to insulate from a pump or a heat exchanger in part.
[0075] here -- insulating piping 105a -- for example, the product made from Teflon (tradename) -- then, it is good Since Teflon is rich in flexibility and is easily bent when it is high insulation, piping connection becomes easy, and since it is chemically stable, high-reliability is acquired.
[0076] next, a conductor -- the circulation way 106 established in a member 103 -- a conductor -- it prepares in the portion near the power semiconductor device 104 so that the thermal resistance of a member 103 may become small If two or more circulation ways 106 are formed at this time, since heat transfer area will increase, cooling efficiency improves.
[0077] In order to increase heat transfer area, the circulation way 106 may be bent, and you may make it spiral, and may make it prepare a fin in the inside of the circulation way 106 similarly, on the other hand, as shown in drawing 10 (b), as shown in drawing 10 (a).
[0078] Next, how to form the circulation way 106 is explained. first, a primary method -- punching tools, such as a drill, -- as it is -- a conductor -- it is the method of opening a hole in a member 103 and forming the circulation way 106
[0079] moreover, the second method -- beforehand -- a conductor -- the member 103 is used as the member of two sheets in the state where it was divided in the thickness direction, it is the method of forming cutting **** for the field where both sides face each other, and the circulation way 106 is obtained by sticking the field cut in this case by soldering etc.
[0080] Here, although a primary method has few processes, a configuration has restrictions and the configuration of a circulation way is restricted to the simple thing which became a straight line. On the other hand, although the process of the method [second] increases, as shown in drawing 10 , it can create the curved complicated configuration and the path of a complicated cross section. since cutting is possible for the above-mentioned copper and the composite material of a copper-acid ghost here -- a conductor -- the member is turned to
[0081] Next, a conductive layer 306 is made from the alloy of copper or aluminum, and makes the front face of the resin insulating layer 102 have rivaled in consideration of electric conduction. While aluminum is lightweight and cheap, as mentioned above, it is the same material as the base board 101, and since the thermal stress produced in the resin insulating layer 102 becomes small at the time of processing for this reason, it is here, suitable as a material which constitutes a conductive layer.
[0082] next, a conductor -- if how to join a conductive layer 306 to a member 103 at the resin insulating layer 102 is explained -- this -- the position on the resin insulating layer 102 -- a binder -- applying -- an each position -- a conductor -- after laying a member 103 and a conductive layer 306, it joins by heating and pressurizing
[0083] therefore, here -- a conductor -- the time of pressurizing, when the thickness of a member 103 and a conductive layer 306 was equal in general -- a conductor -- since a uniform pressure is applied to the plane of composition of a member 103 and a conductive layer 306, and the resin insulating layer 102, good junction can be obtained
[0084] on the other hand -- the circuit pattern 305 -- an insulating layer 401 -- minding -- a conductor -- although joined to the member 103, there is a method of using a resin as a primary method first among the formation methods of the insulating layer 401 at this time in this case,

the thing for which the adhesives of a silicon resin system are used for an insulating layer 401 -- the conductor of the circuit pattern 305 -- the junction and the insulation to a member 103 can attain simultaneously

[0085] Here, since the internal wiring suitably formed in the circuit pattern 305 and this circuit pattern has low resistance and there is little generation of heat produced at the time of operation, there is no need for cooling about them, therefore the low-fever conductivity of silicon resin does not pose a problem.

[0086] On the other hand, if the pinhole is formed in the insulating layer 401 with the air bubbles at the time of an adhesives application etc., since an insulating strength will fall, as for the adhesives at this time, it is desirable to apply to the thickness of 100 to about 600 micrometers. Moreover, it is good to perform adhesion of the circuit pattern 305 simultaneously with heating for the soldered joint of the power semiconductor device 104.

[0087] The second of the formation method of an insulating layer 401 is the method of using a ceramic substrate, and, in the case of this method, the alumina board which deposited silver at the front face and the rear face is used for it. and -- first -- one field of this alumina board -- solder -- minding -- a conductor -- it joins to a member 103 at a conductive layer 306, and the circuit pattern 305 is joined by solder to the field of the another side

[0088] the melting point of the solder used at this time -- a conductor -- it is desirable to suppose that it is in general equivalent to the melting point of the soldered joint layer 107 which joins the power semiconductor device 104 to a member 103 carrying out like this -- the power semiconductor device 104 and a conductor -- it is because a soldered joint, simultaneously soldered joint of a member 103 are obtained

[0089] MOSFET or IGBT is used for the power semiconductor device 104 as a switching element. Selection of in low pressure-proofing using IGBT here using MOSFET when high pressure-proofing is required is possible. MOSFET is used and this operation gestalt uses the parasitism diode of MOSFET for the free wheel diode here so that clearly from drawing 6 .

[0090] On the other hand, in using IGBT as a switching element, it carries separately the free wheel diode which carried out the antiparallel connection to IGBT. moreover -- although this operation gestalt shows the composition which mounted the bare chip -- a conductor -- even if it mounts the discrete device by which the transfer mold was carried out on the member 103 -- the case of a bare chip -- the same -- operation -- possible -- a conductor -- the degree effectively cooled by the member 103 -- each -- a conductor -- the external end-connection child is suitably prepared in the member 103 and the conductive layer 306 like illustration Here, external end-connection child 302a is first connected to an external power circuit. for this reason, this external end-connection child 302a -- a case 303 -- beforehand -- insertion formation -- carrying out -- the power semiconductor device 104 -- a conductor -- the time of pasting up a case 303 on the base board 101, when soldering to a member 103 -- this, simultaneously a conductor -- it is good to join by solder to a member 103 at a conductive layer 306

[0091] Next, the internal connection terminal 308 is suitably formed in the circuit pattern 305. For this reason, although the internal connection terminal 308 is joined by solder to a printed circuit board 307, it may carry electronic parts, such as a capacitor for the driver IC which drives the power semiconductor device 104, the microcomputer which controls the power circuit which consists of this driver IC and a power semiconductor device, gate resistance, and surge absorption, in this printed circuit board 307.

[0092] Moreover, further, external end-connection child 302b is prepared suitably, and, thereby, can connect now with this printed circuit board 307 in an external signal system circuit. by the way, the above-mentioned operation form -- setting -- a conductor -- the front face of a member 103 -- nickel, Ag, Pt, Sn, Sb, Cu, Zn, and Pd with good solder wettability You may make it cover the alloy containing at least one sort of metals chosen from the group, or at least two sorts of metals which were chosen from these groups.

[0093] since the above-mentioned metal or the above-mentioned alloy is equipped with good solder wettability here -- these -- a conductor -- the front face of a member 103 -- a wrap -- the soldering nature of the power semiconductor device 104 will be greatly improved by things,

consequently good junction will be certainly obtained, and much more improvement in reliability can be obtained by them the operation form shown in drawing 3 here -- a conductor -- the front face of a member 103 -- nickel It plates.
[0094] next, the metal or alloy equipped with the above-mentioned good solder wettability in this operation form -- a conductor -- the range covered on the front face of a member 103 is explained first -- as the operation form of this invention -- this covering range -- a conductor -- a part is sufficient although you may be all the front faces of a member 103 Namely, what is necessary is just at least a part.
[0095] here -- first -- a conductor -- supposing it covers on a part of front face of a member 103, the following effects will be acquired in this case for example, Ag etc. -- solder wetting is good -- covering only to a part, when junction nature with aluminum uses a scarce material but -- the soldered joint section of the power semiconductor device 104 -- Ag The good soldered joint by plating is obtained.
[0096] On the other hand, in the portion to which the metal thin line 304 of aluminum is connected, it is Ag. Since there is no plating, junction with the good both sides of the power semiconductor device 104 and the metal thin line 304 can be obtained. Next, a position gap of the power semiconductor device 104 in the time of a soldered joint can be suppressed by a part of covering.
[0097] Although the power semiconductor device 104 may float and it may move from a position when the solder wettability of the covered material is good at this time, and solder fuses at the time of junction If solder wettability covers with a good material beforehand only into the portion to which the power semiconductor device 104 is joined by solder at this time, since the fused solder will not flow out out of this portion There is no possibility that the power semiconductor 104 may move, therefore it can be joined by solder to the position.
[0098] in this case -- in order to form the fillet (flow side) of solder in the circumference of the power semiconductor device 104 finely, or it is the same as the thickness (after-mentioned) of the solder at this time -- several -- solder wetting should just cover the range of a latus size with a good material from the plane of composition of about a time minute and the power semiconductor 104
[0099] It is desirable to make it set to 50 micrometers or more from the standpoint of reduction of heat distortion generated in the soldered joint section as thickness of the soldered joint layer 107 at this time. Therefore, the range which the above-mentioned covering processing section protrudes from the circumference of the power semiconductor 104 serves as about 100 micrometers of numbers from 50 micrometers.
[0100] as the quality of the material of the soldered joint layer 107 used for the power semiconductor device 104 at this time, and junction of a conductive layer 103 -- process temperature -- in view of a low point -- 63%Sn-37% Pb etc. -- what is necessary is just to use the solder of the Sn-Ag, Sn-Ag-Cu, and Sn-Ag-Bi (bismuth) system, when the solder which does not contain lead is required, although the alloy near eutectic composition of tin and lead is desirable
[0101] Here, the soldered joint after piping connection is attained by making the maximum temperature at the time of junction of solder lower than the heat-resistant temperature of insulating piping in the first half in the case of selection of solder. Since a soldered joint is generally performed at temperature higher about 50 degrees C than the melting point at this time, it is good to make the melting point of solder lower 50 degrees C or more than the heat-resistant temperature of the insulating piping 105.
[0102] What is necessary is on the other hand, just to connect piping after a soldered joint, when the maximum temperature of a soldered joint needs to be made higher than the heat-resistant temperature of the insulating piping 105. here -- a conductor -- in case a member 103 is joined to the resin insulating layer 102, pressurization is required as mentioned above therefore, a soldered joint -- a conductor -- the time of making piping connection after a soldered joint, since it becomes a process after the process which joins a member 103 to the resin insulating layer 102 -- a conductor -- the member 103 is already being fixed on the base board 101
[0103] in such a case, it is shown in drawing 11 -- as -- a conductor -- when the entrance and

outlet of the circulation way 106 currently formed in the member 103 consider as the composition it has turned [composition] to the outside, piping connection after a soldered joint can be enabled
[0104] next, the power semiconductor device 104 -- a conductor -- drawing 12 and drawing 13 explain the soldered joint layer 107 for joining to a member 103 Here, drawing 13 provides the stress impingement baffle 1001 in this soldered joint layer 107 between the layer so that clearly [it may be the enlarged view of the A section of drawing 12 and] from these drawings.
[0105] then, the silicon with which the value of the coefficient of linear expansion constitutes the power semiconductor device 104 as a material of this stress impingement baffle 1001 and a conductor -- the heat strain produced in the soldered joint layer 107 can be reduced by using the material between the material which constitutes a member 103
[0106] And as a material of such a stress impingement baffle 1001, thermal conductivity is high, and since solder wettability is good, nickel or the nickel alloy is suitable moreover, although coefficient of linear expansion is low comparatively.
[0107] Since it can prevent that the stress impingement baffle 1001 inclines in the layer of the soldered joint layer 107 by mixing the ball of the nickel of a diameter equivalent to the thickness of this soldered joint layer 107 in the soldered joint layer 107 beforehand at this time and the homogeneity of the thickness of the soldered joint layer 107 is held in it, high-reliability is acquired further.
[0108] Therefore, according to the operation gestalt explained above, it excels in refrigeration capacity, and there is little danger of dielectric breakdown by the crack of an insulating substrate, and it can obtain a highly reliable power semiconductor module easily. Moreover, as a result, a highly reliable power converter can be easily obtained by using the power semiconductor module concerning this operation gestalt.
[0109] Next, semiconductor module ****** concerning other operation forms of this invention, drawing 14 - drawing 17 explain. At this time, drawing 14 expresses the planar structure, drawing 15 expresses the A-A' cross section of drawing 13 , and drawing 16 expresses the B-B' cross section of drawing 13 . in order that drawing 17 may, on the other hand, explain the piping connection method in drawing 14 -- a conductor -- only the power semiconductor device 104 is extracted and shown in a member 103, piping 105, the circulation way 106, the resin insulating layer 102, and it
[0110] the point that the operation form shown in these drawing 14 - drawing 17 differs from the operation form explained by drawing 3 - drawing 5 first here -- drawing 14 and drawing 3 -- comparison ****** -- clear -- as -- mainly -- a conductor -- a member -- it is in the connection form of piping of a between In addition, in respect of others, since it is almost common, the sign same about the same composition is only attached, and detailed explanation is omitted.
[0111] namely, -- the operation form of drawing 3 -- each -- a conductor -- the circulation way 106 of a member 103 is a longitudinal direction drawing, breaks by the last of a series of fluid channels for cooling, and is formed as a ********** path -- receiving -- the operation form of this drawing 14 -- the circulation way 106 -- lengthwise -- becoming -- **** -- a series of fluid channels for cooling -- each -- a conductor -- it is formed as a path which goes and comes back to a member 103 one by one, passes, and goes
[0112] Moreover, as a result, the big difference between these operation forms is also in the application part of insulating piping 105a in a series of fluid channels for cooling. that is, -- although the point of having prepared insulating piping 105a in the connection with the exterior is the same as the operation form of drawing 3 -- the operation form of this drawing 14 -- a conductor -- it is because it is prepared only in the part which whose insulating piping 105a is the part where length is short, and does not have deflection about piping between members 103
[0113] one conductor which insulating piping 105a has in the bottom drawing so that still more clearly, if it explains in detail and drawing 17 will be seen with the operation form of this drawing 14 -- a member -- 103e and three conductors with the bottom -- it is prepared only in a part for the bay between 103f of members It cannot be overemphasized that the direction which does not prepare big curvature in insulating piping 105a unlike metaled piping is excellent in a point

without fear of insulation deterioration here.
[0114] then, with the operation form shown in this drawing 14 - drawing 17 , the entrance and outlet of piping serve as this potential about the part which needs deflection at piping -- as -- a conductor -- a member 103 -- arranging -- thereby -- a conductor -- a member -- 103e and a conductor -- it will be made to have ended if insulating piping 105a is used only for piping between 103f of members
[0115] and -- consequently, a conductor -- a member -- the 103e said ** and a conductor -- a metal with easy molding etc. can use piping 105b of an electrical conducting material for piping of 103f of members, and the fall of the reliability by having bent piping can be prevented from happening to it
[0116] Therefore, insulating piping 105a is restricted to a straight line, and it is not necessary to bend insulating piping 105a, therefore according to this operation form, there is very little fear of degradation of insulating piping by bending, and it is high-reliability. Moreover, as a result, there will be little amount of expensive insulating piping 105a used, and it will end, and low-pricing can be attained.
[0117] next, the conductive layer 306 which serves as a circuit pattern with the operation form of this drawing 13 in order to make the above-mentioned piping configuration possible -- an insulating layer 401 -- minding -- a conductor -- a member -- it has prepared on 103e and differs from the operation form of drawing 3 also at this point
[0118] and this conductive layer 306 -- a conductor -- a member -- the result established on 103e -- a conductor -- a member -- 103e and a conductor -- since between 103f of members turns into space, and it can pipe with a duct without deflection and piping distance becomes small, the size of insulating piping 105a can be shortened
[0119] Since this conductor layer 306 can be formed with good conductors, such as copper and aluminum, at this time, it is not necessary to make thickness into size like the conductive layer 306 in the operation form of drawing 3 . and -- this conductive layer 306 -- a conductor -- a member -- since 103e and the current which counters flow, an inductance falls relatively
[0120] And jumping of voltage when the power semiconductor device 104 turns off becomes small by the fall of this inductance, and fear of destruction of the power semiconductor device 104 by the overvoltage is made few.
[0121] Next, drawing 18 and drawing 19 are the 1 operation forms of this invention at the time of preparing the electrical circuit for an auxiliary machinery drive which becomes from these pumps, a fan, etc. at a heat exchanger 1802, the pump 1801 for cooling water flows, a fan 1803, and it in the power semiconductor module shown in drawing 3 , drawing 18 shows the planar structure and drawing 19 shows the A-A' cross section of drawing 18 .
[0122] Here, the same sign is attached about the same composition as the operation form explained by drawing 3 - drawing 5 , therefore the detailed explanation about these portions is omitted. In these drawing 18 and drawing 19 , the electrical circuit which drives auxiliary machinery is constituted from the 2nd printed circuit board 1703 by the 1st printed circuit board 1702 which consists of a conductive layer for carrying the power semiconductor device 1701 and this power semiconductor device 1701 for auxiliary machinery, and it.
[0123] and -- first -- a printed circuit board 1702 -- a conductor -- it has joined to the resin insulating layer 102 by the member 103 simultaneously heating, and pressurization here -- this printed circuit board 1702 -- a conductor -- inserting a fixture etc. in the portion which the difference of thickness produces, although it is thinner than a member 103 -- a conductor -- it enables it to make it join by the same planar pressure as a member 103
[0124] Next, the 2nd printed circuit board 1703 is also joined to the resin insulating layer 102 simultaneously with a printed circuit board 1702. And although the power semiconductor device 1701 is joined by solder to a printed circuit board 1702 after this, the soldered joint at this time is performed simultaneously with the power semiconductor device 104 which drives a main engine.
[0125] You may carry the circuit which controls the drive of auxiliary machinery, the circuit which controls the drive of a main engine further although other electronic parts are carried, and electronic parts in the 2nd printed circuit board 1703. And this printed circuit board 1703 is

suitably connected with a printed circuit board 307 electrically through the internal connection terminal 308.
[0126] Forced-air cooling of the cooling water 1804 to which temperature rose with the heat which the circulation way 106 of each conductive member 103 was connected [pump / the heat exchanger 1802 and / 1801] through insulating piping 105a, and cooling water 1804 circulated through it with the pump 1801, and was generated in the power semiconductor device 103 is carried out in a heat exchanger 1802 by 1805 of the cooling style supplied by the fan 1803.
[0127] At this time, the heat dissipation from this base board 101 is promoted by making 1805 of the cooling style supplied also to the undersurface of the base board 101 by the fan 1803 guide. By this, cooling of the power semiconductor device 1701 for the auxiliary machinery carried on the printed circuit board 1702 and the circuit element carried in the 2nd printed circuit board 1703 can be aimed at.
[0128] the conductor in which the drive circuit of a main engine established the circulation way 106 at this time -- although cooled by the member 103, the drive circuit of auxiliary machinery radiates heat only by heat transfer from the base board 101 undersurface Therefore, it is made to be located in the upstream of the flow of 1805 of the cooling style like illustration in the 1st printed circuit board 1702 and 2nd printed circuit board 1703.
[0129] However, when [the power of a main engine is / when / large and the base undersurface of the lower part of a main engine goes from the temperature under / of the lower part of auxiliary machinery / the base quantity to auxiliary machinery] becoming, you may arrange so that the drive circuit of a main engine may become the windward of 1805 of the cooling style.
[0130] Next, drawing 20 is 1 operation form of this invention at the time of also making the base board 101 into a water cooling type, and it also forms two pumps 1801, and it is constituted so that cooling water 1804b which radiated heat with the heat exchanger 1801 may circulate through the circulation way 106 established in the base board 101 while establishing the circulation way 106 also in the base board 101 like illustration for this reason.
[0131] Therefore, according to the operation form of this drawing 20 , even if the calorific value of the drive circuit for auxiliary machinery increases, it can respond easily, and it can always cool efficiently, and high-reliability can be planned.
[0132] Next, drawing 21 is 1 operation form at the time of applying to the electronic parts of the automobile by which the air-conditioner (air conditioner : conditioner) is equipped with the semiconductor module concerning this invention, the principal part is constituted from an evaporator 2004 by a compressor 2001, a condenser 2002, an expansion valve 2003, and it, and, as for the air-conditioner for automobiles shown here, predetermined refrigerants, such as a chlorofluorocarbon-replacing material, are enclosed in these interior and piping.
[0133] It operates so that operation which supplies a gas [by which it drove with the engine of the automobile which is not illustrating the compressor 2001, the compressor 2001 inhaled the gas-like refrigerant from an evaporator 2004 by this, it compressed, and temperature rose to the elevated temperature more than ordinary temperature]-like refrigerant to a condenser 2002 may be performed, the interior of a condenser 2002 may be in an elevated-temperature high-pressure state as a result and the interior of an evaporator 2004 may be in a low voltage state.
[0134] At this time, an expansion valve 2003 carries out the work which passes only the liquefied refrigerant, and thereby, it is held without breaking the high-pressure state by the side of a condenser 2002, and the low voltage state by the side of an evaporator 2004.
[0135] Then, if a condenser 2002 is changed into the state where the atmosphere of ordinary temperature **(ed) and the air of the vehicle interior of a room of an automobile is made to ** by the fan who is not illustrating by the evaporator 2004, heat will be taken by the atmosphere of ordinary temperature, and temperature will fall and liquefy the refrigerant of the shape of gas in the elevated temperature in a condenser 2002.
[0136] Then, if this liquefied refrigerant passes an expansion valve 2003 and is supplied to an evaporator 2004, since it is in a low voltage state here, the refrigerant of a liquid will take the evaporation latent heat from the air of the vehicle interior of a room, and will carry out evaporation boil rapidly, it will gasify, and temperature will fall rapidly here.
[0137] Since the refrigerant gasified within the evaporator 2004 is inhaled by the compressor

2001 one after another at this time, the air of the vehicle interior of a room by which there is no inside of an evaporator 2004 in high pressure with a bird clapper, and the evaporation which the refrigerant followed is maintained, consequently the condenser 2002 is **(ed) will be cooled, and the work as an air-conditioner will be obtained.
[0138] then, the path of the refrigerant from an evaporator 2004 to [with the operation form of this drawing 21 , applies any of the semiconductor module by the operation form of this invention described above for this air-conditioner they are, and] a compressor 2001 -- the conductor of a semiconductor module -- it constitutes so that a series of fluid channels for cooling which pass along a member 103 may be contained
[0139] Here, it is the almost same temperature as the air of the vehicle interior of a room currently cooled by the air-conditioner, the refrigerant of the shape of gas which comes out from an evaporator 2004 is in remarkable low temperature rather than ordinary temperature, therefore according to this operation form, it can cool the power semiconductor device 103 still more effectively.
[0140] next, drawing 22 -- the operation form of drawing 21 -- setting -- the conductor of a semiconductor module -- the branch line 2006 which equipped with the control valve 2005 a series of fluid channels for cooling which pass along a member 103 is formed Therefore, since there is a control valve 2005 in the case of this operation form, according to the operating condition of a semiconductor module, the flow rate of the refrigerant by which conduction is carried out there is changeable.
[0141] When the power semiconductor module by the above-mentioned operation form is applied to an automobile, a starter generator is in the target load. The hybrid car of the method it runs with a motor at the time of start is equipped with this starter generator, and short time duty of the power semiconductor module applied to the control is carried out at the time of start.
[0142] that is, -- the time of generation of heat of a power semiconductor module being a short time, therefore a power semiconductor device generating heat in this case, according to the operation form of drawing 22 -- control valve 2005 ** -- opening -- the refrigerant of an air-conditioner -- a conductor -- a power semiconductor device can be effectively cooled by circulating a member 103
[0143]
[Effect of the Invention] According to this invention, it excels in refrigeration capacity, and there is little fear of dielectric breakdown by the crack of an insulating substrate, and a highly reliable power semiconductor module and the power converter using it can be offered.

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* NOTICES *

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TECHNICAL FIELD

[The technical field to which invention belongs] this invention -- the base -- the object for circuit patterns formed through the insulating layer on the surface of the member -- a conductor -- a member -- having -- this object for circuit patterns -- a conductor -- the semiconductor module of the method which carries out soldering junction of the semiconductor chip on the surface of a member is started, especially it is related with the suitable power semiconductor module for the switching element for power conversion, and the power converter using it

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* NOTICES *

PRIOR ART

[Description of the Prior Art] The power semiconductor module which contained the switching element, and IPM (Inteligent Power Module) which built the control circuit in this are large in the field as which high-reliability, such as an automobile and a rail car, is required in recent years, and a use spreads, consequently especially the improvement in reliability is demanded.
[0003] And since switching elements, such as IGBT (insulated-gate bipolar transistor), are also large-capacity-ized and the calorific value of a semiconductor device (semiconductor chip) increases in connection with this at this time, improvement in refrigeration capacity is required strongly. Moreover, although utilization of a hybrid car is progressing in recent years, as for a power semiconductor device, in the case of the hybrid car of the method it runs mainly by the motor (motor), only a short time generates heat greatly for every start here at the time of start.
[0004] Therefore, for such a use, although the maximum of the virtual junction temperature of a power semiconductor device is low, the exothermic-change width of face of a power semiconductor device becomes large, the stress change by thermal expansion and the thermal contraction and the so-called heat rocking also become large, and the number of times also increases. And since especially this heat rocking gives a thermal fatigue to the brazing joint by solder etc., effective cooling is needed for highly reliable grant and highly reliable maintenance.
[0005] By the way, in such a power semiconductor module and IPM, it is common to usually consist of the base which consists of a metal of high temperature conductivity etc., an insulating substrate which consists of material of high temperature conductive and high electric insulation, and a conductive layer in which the circuit pattern was formed in consideration of the numerousness of the calorific value of the power semiconductor device carried, and it is usually at this time that the material of an insulating substrate is chosen according to the calorific value of loading parts.
[0006] And with the product of large capacity [capacity / inside / with big calorific value], as an insulating substrate, although it is expensive, ceramics, such as alumina ceramics with large thermal conductivity and alumimium nitride ceramics, are mainly used. Here, an example of the power semiconductor module by the conventional technology is shown in drawing 23 and drawing 24 .
[0007] This module forms like illustration the power semiconductor device 104 by which soldering junction was carried out on circuit pattern 2102a which has formed in lamination and this ceramic board 2101 the ceramic board 2101 which turns into an insulating substrate in one field (drawing upper field) of the base boards 101, such as copper. At this time, soldering junction of the ceramic board 2101 is carried out at the base board 101 using copper pattern 2102b on the back.
[0008] And after connection by the metal wire 304 was made to this circuit pattern 2102a and wiring to external end-connection child 302a for power and external end-connection child 302b for signals is performed further, it is dedicated in a case 303, and it is closed with a resin 301. In addition, resins are synthetic resin and the so-called plastics here.
[0009] next -- although the base board 101 makes grease 2105 intervene and is attached in a cooling member -- here -- drawing 23 -- cooling of a water cooling type -- air-cooled cooling whose drawing 24 has a fin by the case where it attaches in a member 2104 -- it is the case

where it attaches in a member 2201, and all are fixed to a cooling member by the mounting bolt 2103 at this time

[0010] By the way, since the various material from which coefficient of linear expansion differs is used, as for a power semiconductor module, it is common that curvature is in the base board 101. Here, the directions of this curvature may be the both sides of the direction of a convex where the direction of concave where the center of the plane of composition to the cooling member of the base board 101 has become depressed, and the center of a plane of composition have swollen by parts and the manufacturing process.

[0011] the case where curvature is the direction of concave -- the base and cooling -- a member -- since the thickness of the grease 2105 which is in between increases -- the base and cooling -- a member -- since the contact thermal resistance of a between becomes large, refrigeration capacity declines, the temperature rise of the power semiconductor device 104 is not stopped at the time of operation, there is also a possibility that a performance may fall and break and heat rocking also becomes large, the life of the joint by the soldered joint layer 107 etc. will fall

[0012] On the other hand, when curvature is the direction of a convex and the bolt 2103 for attachment is bound tight, the big bending moment will appear in the ceramic substrate 2101, and a crack will often arise. Here, since, as for the ceramic substrate 2101 which the crack produced, the insulating tolerance dose will be lost, such a semiconductor module will become use impotentia.

[0013] Thus, although there is especially no problem in refrigeration capacity, the power semiconductor module using the ceramic substrate 2101 which is easy to break easily, therefore is shown in drawing 23 and drawing 24 although the ceramic substrate 2101 is a high insulation in high temperature conduction has the danger of producing the fatal defect of dielectric breakdown by the crack of the ceramic substrate 2101, and careful cautions are required for it on the occasion of anchoring.

[0014] On the other hand, by the power semiconductor module of small capacity with comparatively little calorific value, as an insulating substrate, although thermal conductivity is not so high, the quite cheap insulating layer made of a resin is used. Drawing 25 is an example of the small capacity power semiconductor module by the conventional technology, and the resin insulating layer 102 is used instead of the insulating substrate in this case.

[0015] And the conductive layer 306 used as a circuit pattern is formed in this resin insulating layer 102, the power semiconductor device 104 is joined by solder on this conductive layer 306, and other composition is the same as the case of drawing 24 . By the way, when this resin insulating layer 102 is used, curvature as well as the case where the ceramic substrate 2101 is used arises.

[0016] Here, when curvature is the direction of concave, a contact thermal resistance increases similarly and refrigeration capacity declines. On the other hand, when curvature is the direction of a convex, since modulus of direct elasticity is small and stretch is large as compared with the ceramic substrate 2101, there is no possibility of 102 resin insulating layer that it may be divided.

[0017] As mentioned above, the resin insulating layer 102 has a problem in refrigeration capacity, although modulus of direct elasticity is small, thermal conductivity is small although stretch is also large, therefore there is no possibility that, as for the power semiconductor module using the resin electric insulating plate 102 of this drawing 25 , an insulating substrate may break in the case of anchoring.

[0018] By the way, grease 2105 is used by each by the above semiconductor module. Here, since this grease 2105 is silicon resin and the composite material of SERAMMIKU powder, its thermal conductivity is not so high.

[0019] although several steps are excellent rather than there is nothing, since [for this reason,] there is this grease 2105 -- the base and cooling -- a member -- the thermal resistance of a between -- the power semiconductor device 104 and cooling -- if about several percent of the thermal resistance between members will be occupied, therefore a contact thermal resistance in the meantime can be reduced, it can contribute to improvement in refrigeration capacity greatly

[0020] Then, there is a power semiconductor module shown in drawing 26 as the fall of the refrigeration capacity by this contact thermal resistance, and a cure of dielectric breakdown by the crack of an insulating substrate. the module shown in this drawing 26 -- the ceramic substrate 2101 -- direct and brazing -- cooling -- the base board 101 in the semiconductor module which joined to the member 2201, therefore was shown in drawing 24 , and cooling -- the joint between members 2201 does not exist from the beginning

[0021] Therefore, since there is also no layer of the grease by which it should be placed between joints, of course in the case of this module and a contact thermal resistance does not exist in essence, refrigeration capacity improves by leaps and bounds. Moreover, since there is also no anchoring by thread fastening of the base board 101 as a result, there are also few possibilities that the crack by bolting may occur.

[0022] and this time -- cooling -- fear of the crack which the residual stress by the temperature change at the time of junction to the ceramic substrate 2101 and the thermal stress in the time of operation are reduced, consequently is generated in the ceramic substrate 2101 can be suppressed still smaller by constituting a member 2201 from material with small coefficient of linear expansion, such as aluminum-SiC

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3.In the drawings, any words are not translated.

EFFECT OF THE INVENTION

[Effect of the Invention] According to this invention, it excels in refrigeration capacity, and there is little fear of dielectric breakdown by the crack of an insulating substrate, and a highly reliable power semiconductor module and the power converter using it can be offered.

[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] Consideration was not carried out to the point which has a limit in the improvement in refrigeration capacity of a semiconductor device, but the above-mentioned conventional technology had a problem in large-capacity-izing of a semiconductor module, and highly reliable maintenance. First, as described above, the conventional technology shown in drawing 23 or drawing 25 had the problem of the crack of an insulating substrate, and misgiving was in application for the use as which high-reliability is required.
[0024] moreover, such conventional technology needed careful cautions also for anchoring, further, since grease was low-fever conduction, even if it uses this, difficulty stops the contact thermal resistance between a fin and the base small, and the problem was in improvement in refrigeration capacity
[0025] on the other hand, it described above with the conventional technology shown in drawing 26 -- there are few possibilities that the residual stress by the temperature change at the time of ceramic substrate junction and the thermal stress in the time of operation can be reduced, consequently a ceramic substrate may break, by using material with a small coefficient of linear expansion for a cooling member
[0026] However, since it is essentially a weak material and thermal stress also becomes large when the area of a ceramic substrate becomes large by large capacity-ization, ceramics have a possibility that an insulating substrate may break. Moreover, when there is a possibility that a crack may arise in a ceramic substrate when vibration applies to a severe use and a ceramic substrate is used, even if an automobile etc. needs careful cautions for the handling of a power semiconductor module and it faces it maintenance, it is necessary to pay sufficient attention.
[0027] The purpose of this invention is excellent in refrigeration capacity, and is to offer the power converter using the highly reliable power semiconductor module and it with the small danger of dielectric breakdown by the crack of an insulating substrate.

[Translation done.]

* NOTICES *

MEANS

[Means for Solving the Problem] In the semiconductor module of the method which carries out soldering junction of the semiconductor device on the surface of a conductor the above-mentioned purpose -- the base -- the object for circuit patterns formed through the insulating layer on the surface of the member -- a conductor -- having -- this object for circuit patterns -- the aforementioned object for a circuit pattern -- the conductor to which the hole used as the circulation way of a fluid has penetrated the portion of a conductor to which the aforementioned semiconductor device is joined at least inside -- it forms by the member, and it is given with the fluid by which conduction is carried out to the aforementioned circulation way, and thermolysis of the aforementioned semiconductor device makes and is attained
[0029] the conductor which has the aforementioned circulation way at this time -- a member -- two or more pieces -- these conductors -- about at least two in a member The circulation system which the outlet and entrance of those circulation ways become from the heat-exchange equipment which cools the fluid by which may be arranged at the aforementioned base member as is located on the same straight line, and conduction is carried out to the aforementioned circulation way, The aforementioned circulation system is equipped with the electrical circuit which drives the pump which pours a refrigerant, and the aforementioned pump, and the aforementioned electrical circuit may be made to be installed in the aforementioned base member.
[0030] Moreover, at this time, the aforementioned heat-exchange equipment is an air-blast-quenching formula, the aforementioned base member may be made to be cooled more in the style of cooling, or the aforementioned base member has a circulation way inside, and the conduction of the fluid cooled by this circulation way with the aforementioned heat-exchange equipment may be made to be carried out.
[0031] furthermore, the conductor which it has in the aforementioned circulation way -- it may make be the refrigerant with which conduction of the aforementioned fluid to the circulation way concerned of a member was performed through insulating piping, it could constitute so that the melting point of this insulating piping might become higher than the melting point of the brazing filler metal used for the aforementioned soldering junction, and the aforementioned fluid branched from the air-conditioner equipment currently installed separately
[0032] Similarly the above-mentioned purpose is attained by constituting a power converter in one of the above, using the semiconductor module of a publication as a switching element of a main circuit.
[0033]
[Embodiments of the Invention] First, before explaining concretely about the gestalt of operation of this invention, the plan of drawing 1 and the side elevation of drawing 2 explain the fundamental composition of this operation gestalt briefly here. In these drawing 1 and drawing 2 , first, 101 is a base board and the resin insulating layer 102 is formed in one field of this base board 101. 103 [next,] -- a conductor -- the circuit pattern to which it is a member, and it is divided into some portions and a semiconductor device is joined by this like illustration -- a conductor is formed
[0034] and -- each -- a conductor -- through the resin insulating layer 102, a member 103 is

arranged on the base board 101, and is joined to the base board 101 by the resin insulating layer 102 — having — **** — these — each — a conductor — each power semiconductor device 104 is joined to the exposed surface of a member 103 by the soldered joint layer 107
[0035] here — each — a conductor — it has predetermined thickness as a member 103 is made from electrical conducting materials, such as copper, and it is expressed to drawing 2 , and the hole which becomes the thickness direction and a right angle with the path of the fluid for cooling to the interior, respectively is formed as a circulation way 106 of a-two round trip
[0036] and these circulation ways 106 are mutually open for free passage with the piping 105 currently made from the insulating material, i.e., insulating piping, — having — each — a conductor — it passes along the circulation way 106 of a-two round trip of a member 103, and it is made so that a series of fluid channels for cooling may break and it may be formed as a ********** path
[0037] then, the piping 105 — minding — each — a conductor — if the circulation way 106 of a member 103 is made to carry out conduction of the fluid used as a predetermined coolant, for example, the water of predetermined temperature, — each — a conductor — the circuit pattern to each power semiconductor device 104 which boils a member 103, respectively and is joined — while forming a conductor, it will work also as a member which cools each power semiconductor device 104
[0038] here according to the composition of these drawing 1 and drawing 2 — each — a conductor — since it decreases sharply as compared with the case where the soldered joint layer 107 only intervened, and the cooling water in the circulation way 106 and the thermal resistance between the power semiconductor devices 104 were very small for it, and it is placed between them by the conventional insulating substrate since all [the heat transfer path between a member 103 and the power semiconductor device 104 / the insulator], a high cooling performance is obtained easily
[0039] moreover, since piping 105 has been carried out to insulating piping at this time, it is in different potential — each — a conductor — the insulation needed between members 103 obtains easily — having — a conductor — formation of the circuit pattern by the member 103 also becomes easy moreover, this time — each — a conductor — on the base board 101, two or more members 103 are put in order and arranged
[0040] then — each — a conductor — the entrance and outlet of the circulation way 106 of a member 103 are arranged on the same straight line By this, the entrance and outlet of each circulation way 106 can face each other on a straight line, and can make it arrange, connection of piping can be performed easily, and brief piping can be formed.
[0041] by the way — each — a conductor — since the circulation way 106 is formed into it, it is necessary to thicken a member 103 far as compared with the conductor layer in a common circuit pattern here — this conductor — if the thickness of a member 103 increases, the thermal stress generated at the time of processing and operation will become large according to the difference of coefficient of linear expansion with the base board 101
[0042] however, the thing for which modulus of direct elasticity is small to the resin insulating layer 102, and stretch applies a large material to it here — a conductor with big thickness — even if it joins a member 103 to the base board 101, there is no possibility of inviting the insulating fall by the crack and the crack to the resin insulating layer 102 by thermal stress
[0043] this time — heat dissipation of the power semiconductor device 104 — a conductor — since the inside of the circulation way 106 of a member 103 is depended on heat transfer of the flowing cooling water, and the value of heat conduction of the resin insulating layer 102 does not become a problem at all, as described above, the quality of the material from which generating of a crack does not take place can be chosen arbitrarily
[0044] Next, the form of implementation of illustration explains the power semiconductor module by this invention concretely. However, this invention is not restricted to the form of the operation explained below.
[0045] First, drawing 3 , drawing 4 , and drawing 5 are the forms of the 1 operation at the time of applying this invention to a power semiconductor module including a three-phase-circuit power circuit, drawing 3 expresses the planar structure and, as for drawing 4 , the A-A cross section of

drawing 3 and drawing 5 express the B-B' cross section of drawing 3 here.
[0046] Moreover, drawing 6 is the equal circuit of this three-phase-circuit power circuit, and that of the sign for each terminal area is the same as that of the sign in the terminal of drawing 3 . In addition, this equal circuit is used as an inverter of a three phase circuit.
[0047] the conductor which the power semiconductor module by this operation form forms the resin insulating layer 102 used as an insulating substrate in one field (field of the direction which has turned up in drawing 4) of the base board 101 in these drawings, and has the circulation way 106 on it -- the conductive layer 306 used as a member 103 and other circuit patterns -- joining -- this conductor -- the power semiconductor device 104 is joined to the position on a member 103 by the soldered joint layer 107
[0048] and -- each -- a conductor -- it is mutually open for free passage with insulating piping 105a, and the circulation way 106 of a member 103 is pulled out outside moreover -- each -- a conductor -- on the member 103, another circuit pattern 305 is joined through the insulating layer 401
[0049] furthermore, the power semiconductor device 104 and a conductor -- the conductive layer 306 is connected to a member 103, the circuit pattern 305, and it by the metal thin line 304, respectively (omitted in drawing 4) Here, the wire of the aluminium alloy about 300-500 micrometerphi is used for these metal thin lines 304.
[0050] moreover, a conductor -- the internal connection terminal 308 and the external end-connection child 302 are suitably formed in the member 103, the circuit pattern 305, and the conductive layer 306, the printed circuit board 307 is connected to the internal connection terminal 308 (the dashed line shows only the appearance of a printed circuit board 307 to drawing 3), and external end-connection child 302b is further prepared in this lint substrate 307 suitably
[0051] here, with this operation gestalt, a case 303 pastes the base board 101 through the resin insulating layer 102 -- **** (the dashed line shows only the appearance of a case to drawing 3) -- using the PPS (polyphenylene sulfide) resin which has thermal resistance as a material of a case 303 at this time -- the power semiconductor device 104 and a conductor -- the junction, simultaneously the case 303 by the solder of a member 103 can be pasted up on the resin insulating layer 102
[0052] and these conductors -- some external end-connection children 302 are closed by a part of member 103, insulating piping 105, a conductive layer 305, the circuit pattern 305, the power semiconductor device 104, the metal thin line 304, the internal wiring 308, and it with the resin 301 with high thermal conductivity, and he is completed as a power semiconductor module
[0053] In order that a closure resin may prevent having a bad influence on a metal thin line or an element at the time of closure, and the time of use, you may make it use comparatively soft material, such as silicon gel, although it is common at this time to use stiff thermosetting resin comparatively, such as an epoxy resin, to the resin 301 for this closure.
[0054] Furthermore, if it explains concretely, the base board 101 is first made from lightweight and cheap aluminum or an aluminium alloy. This is because it is suitable for the aluminum which is cheap and can do it lightweight as compared with copper since this base board 101 has comparatively big volume within a power semiconductor module producing a power semiconductor module.
[0055] On the other hand, when a cooling performance is thought as important, copper with still higher thermal conductivity is used. At this time, the base board 101 is made into the thickness of at least 2mm, and may be made into the thickness of about 30mm so that reduction of the thermal resistance by the breadth of the heat in the interior may fully be obtained. Here, you may prepare the fin further for forced-air cooling, or the water-cooled tube for water cooling in this base board 101.
[0056] Next, since high insulation is required, for this reason, the epoxy resin by which the filler was distributed is used for the resin insulating layer 102 used as an insulating substrate. In addition, thereby, low-fever resistance is also given.
[0057] And since a modulus of longitudinal elasticity is small as compared with a ceramic board and stretch is large, the resin insulating layer 102 by the epoxy resin by which this filler was

distributed does not have a possibility that it may be divided also with the thermal stress at the time of junction and operation.
[0058] Here, that what is necessary is just to use for a filler what was made from the inorganic compound of high temperature conductivity of for example, oxidization silicon, an aluminum oxide, etc., the thermal resistance of the resin insulating layer 102 can be reduced, so that the content of a filler is increased at this time.
[0059] However, since there is a limitation in the amount of fillers which can be distributed in an epoxy resin, it is good to usually make content of a filler into 75 - 95% of range, and the thermal conductivity of the resin insulating layer 102 serves as the range of 2 - 5 W/mK in this case.
[0060] On the other hand, an option effective in reducing the thermal resistance of the resin insulating layer 102 is making it thin. However, if the resin insulating layer 102 is made thin, although there will be a possibility that may become easy to generate a pinhole etc. in a resin insulating layer, and reliability may fall to it when the part and isolation voltage fall, therefore there will be a limitation in the minimum of the thickness of the resin insulating layer 102 and it will be based also on the isolation voltage demanded, about 50-250 micrometers becomes a minimum.
[0061] It is better to be thicker than the case of the conventional power semiconductor module here, since relief of the thermal stress at the time of processing and operation is required rather than reduction of thermal resistance about this resin insulating layer in the case of this invention.
[0062] moreover, this resin insulating layer 102 -- a conductor -- the creeping distance which is equivalent also to these circumferences at isolation voltage since a member 103 and a conductive layer 306 are insulated from the base board 101 -- required -- this sake -- an insufficient part -- the front face of the base board 101 -- an insulating layer -- a wrap -- it is necessary to compensate with things
[0063] then -- this operation gestalt -- illustration -- like -- this resin insulating layer 102 -- the conductor of the base board 101 -- it has prepared all over the member 103 side next, a conductor -- as a material of a member 103, when it gives priority to heat conduction, the alloy of copper or aluminum is chosen
[0064] Although there is an advantage that aluminum is lightweight, at this time, since coefficient of linear expansion is large, a problem is in the reliability of the soldered joint layer 107 which joins the power semiconductor device 104, and the use of which high-reliability is required is not turned to. on the other hand -- copper -- aluminum -- comparing -- low-fever expansibility and high temperature conductivity -- it is -- therefore, a conductor -- it is suitable for the member 103
[0065] moreover, the power semiconductor device 104 and a conductor -- the case where the reliability of the soldered joint layer 107 which joins a member 103 is taken into consideration -- a conductor -- coefficient of linear expansion chooses material with comparatively high near and thermal conductivity as the silicon which forms the power semiconductor device 104 as a member 103
[0066] although there are molybdenum, an aluminum silicon carbide (aluminum-SiC), copper, composite material of a copper-acid ghost, etc. as a material which corresponds at this time -- this conductor -- since it is necessary to establish the circulation way 106 in a member 103, in consideration of processability, it can be said that copper and the composite material of a copper-acid ghost are the optimal
[0067] the time of this copper and the composite material of a copper-acid ghost being able to change coefficient of linear expansion and thermal conductivity with the ratio of copper and a copper-acid ghost, and the ratio of a copper-acid ghost being 30% here -- coefficient of linear expansion -- 13.5x10-6 / K -- it is -- thermal conductivity -- 240 W/mK -- becoming -- this -- a conductor -- it is suitable for the member 103
[0068] next -- each -- a conductor -- it is made for a member 103 to have the entrance and outlet of the circulation way 106 on a straight line When it is made for an entrance and an outlet to be on a straight line, it can constitute from same parts and there is an advantage of making piping connection easily.

[0069] here — the operation gestalt of drawing 3 — one conductor — a member — everything but 103a — the conductor of the same configuration — although 103bis located in a line and arranged three members, if the entrance and the outlet were located in a line on the straight line like illustration at this time, when the same parts will have been arranged side by side, piping connection of each entrance and outlet is made as it is
[0070] Next, the piping connection method at this time is explained. after making piping connection with the operation gestalt of drawing 3 -- a conductive layer 306 and a conductor -- a member 103 is joined to the resin insulating layer 102, and drawing 9 explains the procedure of the piping connection at this time from drawing 7
[0071] that these drawings indicated piping connection sequence to be -- it is -- the direction of an arrow -- piping 105 and a conductor -- piping is connected by moving a member 103 an assembly efficient here sake -- each -- a conductor -- a member -- it is good it to become requirements that the entrance and outlet of the circulation way 106 in 103b are on a straight line and to provide sufficient space for the opposite side of the piping connection direction, and to make it a piping path become a picture drawn without lifting the brush from the paper like illustration further
[0072] by the way -- each -- a conductor -- since a member 103 is a conductor which forms a circuit pattern and has become wiring of a part of circuit shown in drawing 6 -- a conductor -- a member -- the case where it becomes the potential from which 103 comrades differ -- it is -- this case -- a conductor -- it is necessary to use insulating piping for connecting the circulation way 106 of a member 103
[0073] With the operation gestalt of drawing 3 , since conductive member 103 differs in potential, respectively, it has piped by insulating piping 105a. however, the conductor which becomes this potential -- a member -- piping of comrades does not need to be insulating piping Here, piping 105b of drawing 3 is not insulating piping.
[0074] Insulating piping 105a is prepared in piping connected to the pump for cooling water flows which is outside on the other hand, and piping linked to the heat exchanger for cooling of the water which carried out the temperature rise by generation of heat of a power semiconductor device, and it is made to insulate from a pump or a heat exchanger in part.
[0075] here — insulating piping 105a -- for example, the product made from Teflon (tradename) -- then, it is good Since Teflon is rich in flexibility and is easily bent when it is high insulation, piping connection becomes easy, and since it is chemically stable, high-reliability is acquired.
[0076] next, a conductor -- the circulation way 106 established in a member 103 -- a conductor -- it prepares in the portion near the power semiconductor device 104 so that the thermal resistance of a member 103 may become small If two or more circulation ways 106 are formed at this time, since heat transfer area will increase, cooling efficiency improves.
[0077] In order to increase heat transfer area, the circulation way 106 may be bent, and you may make it spiral, and may make it prepare a fin in the inside of the circulation way 106 similarly, on the other hand, as shown in drawing 10 (b), as shown in drawing 10 (a).
[0078] Next, how to form the circulation way 106 is explained. first, a primary method -- punching tools, such as a drill, — as it is -- a conductor -- it is the method of opening a hole in a member 103 and forming the circulation way 106
[0079] moreover, the second method -- beforehand -- a conductor -- the member 103 is used as the member of two sheets in the state where it was divided in the thickness direction, it is the method of forming cutting **** for the field where both sides face each other, and the circulation way 106 is obtained by sticking the field cut in this case by soldering etc.
[0080] Here, although a primary method has few processes, a configuration has restrictions and the configuration of a circulation way is restricted to the simple thing which became a straight line. On the other hand, although the process of the method [second] increases, as shown in drawing 10 , it can create the curved complicated configuration and the path of a complicated cross section. since cutting is possible for the above-mentioned copper and the composite material of a copper-acid ghost here -- a conductor -- the member is turned to
[0081] Next, a conductive layer 306 is made from the alloy of copper or aluminum, and makes the front face of the resin insulating layer 102 have rivaled in consideration of electric

conduction. While aluminum is lightweight and cheap, as mentioned above, it is the same material as the base board 101, and since the thermal stress produced in the resin insulating layer 102 becomes small at the time of processing for this reason, it is here, suitable as a material which constitutes a conductive layer.
[0082] next, a conductor -- if how to join a conductive layer 306 to a member 103 at the resin insulating layer 102 is explained -- this -- the position on the resin insulating layer 102 -- a binder -- applying -- an each position -- a conductor -- after laying a member 103 and a conductive layer 306, it joins by heating and pressurizing
[0083] therefore, here -- a conductor -- the time of pressurizing, when the thickness of a member 103 and a conductive layer 306 was equal in general -- a conductor -- since a uniform pressure is applied to the plane of composition of a member 103 and a conductive layer 306, and the resin insulating layer 102, good junction can be obtained
[0084] on the other hand -- the circuit pattern 305 -- an insulating layer 401 -- minding -- a conductor -- although joined to the member 103, there is a method of using a resin as a primary method first among the formation methods of the insulating layer 401 at this time in this case, the thing for which the adhesives of a silicon resin system are used for an insulating layer 401 -- the conductor of the circuit pattern 305 -- the junction and the insulation to a member 103 can attain simultaneously
[0085] Here, since the internal wiring suitably formed in the circuit pattern 305 and this circuit pattern has low resistance and there is little generation of heat produced at the time of operation, there is no need for cooling about them, therefore the low-fever conductivity of silicon resin does not pose a problem.
[0086] On the other hand, if the pinhole is formed in the insulating layer 401 with the foam at the time of an adhesives application etc., since an insulating strength will fall, as for the adhesives at this time, it is desirable to apply to the thickness of 100 to about 600 micrometers. Moreover, it is good to perform adhesion of the circuit pattern 305 simultaneously with heating for the soldered joint of the power semiconductor device 104.
[0087] The second of the formation method of an insulating layer 401 is the method of using a ceramic substrate, and, in the case of this method, the alumina board which deposited silver at the front face and the rear face is used for it. and -- first -- one field of this alumina board -- solder -- minding -- a conductor -- it joins to a member 103 at a conductive layer 306, and the circuit pattern 305 is joined by solder to the field of the another side
[0088] the melting point of the solder used at this time -- a conductor -- it is desirable to suppose that it is in general equivalent to the melting point of the soldered joint layer 107 which joins the power semiconductor device 104 to a member 103 carrying out like this -- the power semiconductor device 104 and a conductor -- it is because a soldered joint, simultaneously soldered joint of a member 103 are obtained
[0089] MOSFET or IGBT is used for the power semiconductor device 104 as a switching element. Selection of in low pressure-proofing using IGBT here using MOSFET when high pressure-proofing is required is possible. MOSFET is used and this operation gestalt uses the parasitism diode of MOSFET for the free wheel diode here so that clearly from drawing 6 .
[0090] On the other hand, in using IGBT as a switching element, it carries separately the free wheel diode which carried out the antiparallel connection to IGBT. moreover -- although this operation gestalt shows the composition which mounted the bare chip -- a conductor -- even if it mounts the discrete device by which the transfer mold was carried out on the member 103 -- the case of a bare chip -- the same -- operation -- possible -- a conductor -- the degree effectively cooled by the member 103 -- each -- a conductor -- the external end-connection child is suitably prepared in the member 103 and the conductive layer 306 like illustration Here, external end-connection child 302a is first connected to an external power circuit. for this reason, this external end-connection child 302a -- a case 303 -- beforehand -- insertion formation -- carrying out -- the power semiconductor device 104 -- a conductor -- the time of pasting up a case 303 on the base board 101, when soldering to a member 103 -- this, simultaneously a conductor -- it is good to join by solder to a member 103 at a conductive layer 306

[0091] Next, the internal connection terminal 308 is suitably formed in the circuit pattern 305. For this reason, although the internal connection terminal 308 is joined by solder to a printed circuit board 307, it may carry electronic parts, such as a capacitor for the driver IC which drives the power semiconductor device 104, the microcomputer which controls the power circuit which consists of this driver IC and a power semiconductor device, gate resistance, and surge absorption, in this printed circuit board 307.
[0092] Moreover, further, external end-connection child 302b is prepared suitably, and, thereby, can connect now with this printed circuit board 307 in an external signal system circuit. by the way, the above-mentioned operation gestalt -- setting -- a conductor -- the front face of a member 103 -- nickel, Ag, Pt, Sn, Sb, Cu, Zn, and Pd with good solder wettability You may make it cover the alloy containing at least one sort of metals chosen from the group, or at least two sorts of metals which were chosen from these groups.
[0093] since the above-mentioned metal or the above-mentioned alloy is equipped with good solder wettability here -- these -- a conductor -- the front face of a member 103 -- a wrap -- the soldering nature of the power semiconductor device 104 will be greatly improved by things, consequently good junction will be certainly obtained, and much more improvement in reliability can be obtained by them the operation gestalt shown in drawing 3 here -- a conductor -- the front face of a member 103 -- nickel It plates.
[0094] next, the metal or alloy equipped with the above-mentioned good solder wettability in this operation gestalt -- a conductor -- the range covered on the front face of a member 103 is explained first -- as the operation gestalt of this invention -- this covering range -- a conductor -- a part is sufficient although you may be all the front faces of a member 103 Namely, what is necessary is just at least a part.
[0095] here -- first -- a conductor -- supposing it covers on a part of front face of a member 103, the following effects will be acquired in this case for example, Ag etc. -- solder wetting is good -- covering only to a part, when junction nature with aluminum uses a scarce material but -- the soldered joint section of the power semiconductor device 104 -- Ag The good soldered joint by plating is obtained.
[0096] On the other hand, in the portion to which the metal thin line 304 of aluminum is connected, it is Ag. Since there is no plating, junction with the good both sides of the power semiconductor device 104 and the metal thin line 304 can be obtained. Next, a position gap of the power semiconductor device 104 in the time of a soldered joint can be suppressed by a part of covering.
[0097] Although the power semiconductor device 104 may float and it may move from a position when the solder wettability of the covered material is good at this time, and solder fuses at the time of junction If solder wettability covers with a good material beforehand only into the portion to which the power semiconductor device 104 is joined by solder at this time, since the fused solder will not flow out out of this portion There is no possibility that the power semiconductor 104 may move, therefore it can be joined by solder to the position.
[0098] in this case -- in order to form the fillet (flow side) of solder in the circumference of the power semiconductor device 104 finely, or it is the same as the thickness (after-mentioned) of the solder at this time -- several -- solder wetting should just cover the range of a latus size with a good material from the plane of composition of about a time minute and the power semiconductor 104
[0099] It is desirable to make it set to 50 micrometers or more from the standpoint of reduction of heat distortion generated in the soldered joint section as thickness of the soldered joint layer 107 at this time. Therefore, the range which the above-mentioned covering processing section protrudes from the circumference of the power semiconductor 104 serves as about 100 micrometers of numbers from 50 micrometers.
[0100] as the quality of the material of the soldered joint layer 107 used for the power semiconductor device 104 at this time, and junction of a conductive layer 103 -- process temperature -- in view of a low point -- 63%Sn-37% Pb etc. -- what is necessary is just to use the solder of the Sn-Ag, Sn-Ag-Cu, and Sn-Ag-Bi (bismuth) system, when the solder which does not contain lead is required, although the alloy near eutectic composition of tin and lead is

desirable
[0101] Here, the soldered joint after piping connection is attained by making the maximum temperature at the time of junction of solder lower than the heat-resistant temperature of insulating piping in the first half in the case of selection of solder. Since a soldered joint is generally performed at temperature higher about 50 degrees C than the melting point at this time, it is good to make the melting point of solder lower 50 degrees C or more than the heat-resistant temperature of the insulating piping 105.
[0102] What is necessary is on the other hand, just to connect piping after a soldered joint, when the maximum temperature of a soldered joint needs to be made higher than the heat-resistant temperature of the insulating piping 105. here -- a conductor -- in case a member 103 is joined to the resin insulating layer 102, pressurization is required as mentioned above therefore, a soldered joint -- a conductor -- the time of making piping connection after a soldered joint, since it becomes a process after the process which joins a member 103 to the resin insulating layer 102 -- a conductor -- the member 103 is already being fixed on the base board 101
[0103] in such a case, it is shown in drawing 11 -- as -- a conductor -- when the entrance and outlet of the circulation way 106 currently formed in the member 103 consider as the composition it has turned [composition] to the outside, piping connection after a soldered joint can be enabled
[0104] next, the power semiconductor device 104 -- a conductor -- drawing 12 and drawing 13 explain the soldered joint layer 107 for joining to a member 103 Here, drawing 13 provides the stress impingement baffle 1001 in this soldered joint layer 107 between the layer so that clearly [it may be the enlarged view of the A section of drawing 12 and] from these drawings.
[0105] then, the silicon with which the value of the coefficient of linear expansion constitutes the power semiconductor device 104 as a material of this stress impingement baffle 1001 and a conductor -- the heat strain produced in the soldered joint layer 107 can be reduced by using the material between the material which constitutes a member 103
[0106] And as a material of such a stress impingement baffle 1001, thermal conductivity is high, and since solder wettability is good, nickel or the nickel alloy is suitable moreover, although coefficient of linear expansion is low comparatively.
[0107] Since it can prevent that the stress impingement baffle 1001 inclines in the layer of the soldered joint layer 107 by mixing the ball of the nickel of a diameter equivalent to the thickness of this soldered joint layer 107 in the soldered joint layer 107 beforehand at this time and the homogeneity of the thickness of the soldered joint layer 107 is held in it, high-reliability is acquired further.
[0108] Therefore, according to the operation gestalt explained above, it excels in refrigeration capacity, and there is little danger of dielectric breakdown by the crack of an insulating substrate, and it can obtain a highly reliable power semiconductor module easily. Moreover, as a result, a highly reliable power converter can be easily obtained by using the power semiconductor module concerning this operation gestalt.
[0109] Next, semiconductor module ****** concerning other operation gestalten of this invention, drawing 14 - drawing 17 explain. At this time, drawing 14 expresses the planar structure, drawing 15 expresses the A-A' cross section of drawing 13 , and drawing 16 expresses the B-B' cross section of drawing 13 . in order that drawing 17 may, on the other hand, explain the piping connection method in drawing 14 -- a conductor -- only the power semiconductor device 104 is extracted and shown in a member 103, piping 105, the circulation way 106, the resin insulating layer 102, and it
[0110] the point that the operation gestalt shown in these drawing 14 - drawing 17 differs from the operation gestalt explained by drawing 3 - drawing 5 first here -- drawing 14 and drawing 3 -- comparison ****** -- clear -- as -- mainly -- a conductor -- a member -- it is in the connection form of piping of a between In addition, in respect of others, since it is almost common, the sign same about the same composition is only attached, and detailed explanation is omitted.
[0111] namely, -- the operation gestalt of drawing 3 -- each -- a conductor -- the circulation way 106 of a member 103 is a longitudinal direction drawing, breaks by the last of a series of

fluid channels for cooling, and is formed as a ********** path -- receiving -- the operation gestalt of this drawing 14 -- the circulation way 106 -- lengthwise -- becoming -- **** -- a series of fluid channels for cooling -- each -- a conductor -- it is formed as a path which goes and comes back to a member 103 one by one, passes, and goes

[0112] Moreover, as a result, the big difference between these operation gestalten is also in the application part of insulating piping 105a in a series of fluid channels for cooling. that is, -- although the point of having prepared insulating piping 105a in the connection with the exterior is the same as the operation gestalt of drawing 3 -- the operation gestalt of this drawing 14 -- a conductor -- it is because it is prepared only in the part which whose insulating piping 105a is the part where length is short, and does not have deflection about piping between members 103

[0113] one conductor which insulating piping 105a has in the bottom drawing so that still more clearly, if it explains in detail and drawing 17 will be seen with the operation gestalt of this drawing 14 -- a member -- 103e and three conductors with the bottom -- it is prepared only in a part for the bay between 103f of members It cannot be overemphasized that the direction which does not prepare big curvature in insulating piping 105a unlike metaled piping is excellent in a point without fear of insulation deterioration here.

[0114] then, with the operation gestalt shown in this drawing 14 - drawing 17 , the entrance and outlet of piping serve as this potential about the part which needs deflection at piping -- as -- a conductor -- a member 103 -- arranging -- thereby -- a conductor -- a member -- 103e and a conductor -- it will be made to have ended if insulating piping 105a is used only for piping between 103f of members

[0115] and -- consequently, a conductor -- a member -- the 103e said ** and a conductor -- a metal with easy molding etc. can use piping 105b of an electrical conducting material for piping of 103f of members, and the fall of the reliability by having bent piping can be prevented from happening to it

[0116] Therefore, insulating piping 105a is restricted to a straight line, and it is not necessary to bend insulating piping 105a, therefore according to this operation gestalt, there is very little fear of degradation of insulating piping by bending, and it is high-reliability. Moreover, as a result, there will be little amount of expensive insulating piping 105a used, and it will end, and low-pricing can be attained.

[0117] next, the conductive layer 306 which serves as a circuit pattern with the operation gestalt of this drawing 13 in order to make the above-mentioned piping configuration possible -- an insulating layer 401 -- minding -- a conductor -- a member -- it has prepared on 103e and differs from the operation gestalt of drawing 3 also at this point

[0118] and this conductive layer 306 -- a conductor -- a member -- the result established on 103e -- a conductor -- a member -- 103e and a conductor -- since between 103f of members turns into space, and it can pipe with a duct without deflection and piping distance becomes small, the size of insulating piping 105a can be shortened

[0119] Since this conductor layer 306 can be formed with good conductors, such as copper and aluminum, at this time, it is not necessary to make thickness into size like the conductive layer 306 in the operation gestalt of drawing 3 . and -- this conductive layer 306 -- a conductor -- a member -- since 103e and the current which counters flow, an inductance falls relatively

[0120] And jumping of voltage when the power semiconductor device 104 turns off becomes small by the fall of this inductance, and fear of destruction of the power semiconductor device 104 by the overvoltage is made few.

[0121] Next, drawing 18 and drawing 19 are the 1 operation gestalten of this invention at the time of preparing the electrical circuit for an auxiliary machinery drive which becomes from these pumps, a fan, etc. at a heat exchanger 1802, the pump 1801 for cooling water flows, a fan 1803, and it in the power semiconductor module shown in drawing 3 , drawing 18 shows the planar structure and drawing 19 shows the A-A' cross section of drawing 18 .

[0122] Here, the same sign is attached about the same composition as the operation gestalt explained by drawing 3 - drawing 5 , therefore the detailed explanation about these portions is omitted. In these drawing 18 and drawing 19 , the electrical circuit which drives auxiliary machinery is constituted from the 2nd printed circuit board 1703 by the 1st printed circuit board

1702 which consists of a conductive layer for carrying the power semiconductor device 1701 and this power semiconductor device 1701 for auxiliary machinery, and it.
[0123] and — first — a printed circuit board 1702 — a conductor — it has joined to the resin insulating layer 102 by the member 103 simultaneously heating, and pressurization here — this printed circuit board 1702 — a conductor — inserting a fixture etc. in the portion which the difference of thickness produces, although it is thinner than a member 103 — a conductor — it enables it to make it join by the same planar pressure as a member 103
[0124] Next, the 2nd printed circuit board 1703 is also joined to the resin insulating layer 102 simultaneously with a printed circuit board 1702. And although the power semiconductor device 1701 is joined by solder to a printed circuit board 1702 after this, the soldered joint at this time is performed simultaneously with the power semiconductor device 104 which drives a main engine.
[0125] You may carry the circuit which controls the drive of auxiliary machinery, the circuit which controls the drive of a main engine further although other electronic parts are carried, and electronic parts in the 2nd printed circuit board 1703. And this printed circuit board 1703 is suitably connected with a printed circuit board 307 electrically through the internal connection terminal 308.
[0126] Forced-air cooling of the cooling water 1804 to which temperature rose with the heat which the circulation way 106 of each conductive member 103 was connected [pump / the heat exchanger 1802 and / 1801] through insulating piping 105a, and cooling water 1804 circulated through it with the pump 1801, and was generated in the power semiconductor device 103 is carried out in a heat exchanger 1802 by 1805 of the cooling style supplied by the fan 1803.
[0127] At this time, the thermolysis from this base board 101 is promoted by making 1805 of the cooling style supplied also to the inferior surface of tongue of the base board 101 by the fan 1803 guide. By this, cooling of the power semiconductor device 1701 for the auxiliary machinery carried on the printed circuit board 1702 and the circuit element carried in the 2nd printed circuit board 1703 can be aimed at.
[0128] the conductor in which the drive circuit of a main engine established the circulation way 106 at this time — although cooled by the member 103, the drive circuit of auxiliary machinery radiates heat only by heat transfer from base board 101 inferior surface of tongue Therefore, it is made to be located in the upstream of the flow of 1805 of the cooling style like illustration in the 1st printed circuit board 1702 and 2nd printed circuit board 1703.
[0129] However, when [the power of a main engine is / when / large and the base inferior surface of tongue of the lower part of a main engine goes from the temperature under / of the lower part of auxiliary machinery / the base quantity to auxiliary machinery] becoming, you may arrange so that the drive circuit of a main engine may become the windward of 1805 of the cooling style.
[0130] Next, drawing 20 is 1 operation gestalt of this invention at the time of also making the base board 101 into a water cooling type, and it also forms two pumps 1801, and it is constituted so that cooling water 1804b which radiated heat with the heat exchanger 1801 may circulate through the circulation way 106 established in the base board 101 while establishing the circulation way 106 also in the base board 101 like illustration for this reason.
[0131] Therefore, according to the operation gestalt of this drawing 20 , even if the calorific value of the drive circuit for auxiliary machinery increases, it can respond easily, and it can always cool efficiently, and high-reliability can be planned.
[0132] Next, drawing 21 is 1 operation gestalt at the time of applying to the electronic parts of the automobile by which the air-conditioner (air conditioner : conditioner) is equipped with the semiconductor module concerning this invention, the principal part is constituted from an evaporator 2004 by a compressor 2001, a condenser 2002, an expansion valve 2003, and it, and, as for the air-conditioner for automobiles shown here, predetermined refrigerants, such as a chlorofluorocarbon-replacing material, are enclosed in these interior and piping.
[0133] It operates so that operation which supplies a gas [by which it drove with the engine of the automobile which is not illustrating the compressor 2001, the compressor 2001 inhaled the gas-like refrigerant from an evaporator 2004 by this, it compressed, and temperature rose to the

elevated temperature more than ordinary temperature]-like refrigerant to a condenser 2002 may be performed, the interior of a condenser 2002 may be in an elevated-temperature high-pressure state as a result and the interior of an evaporator 2004 may be in a low voltage state.
[0134] At this time, an expansion valve 2003 carries out the work which passes only the liquefied refrigerant, and thereby, it is held without breaking the high-pressure state by the side of a condenser 2002, and the low voltage state by the side of an evaporator 2004.
[0135] Then, if a condenser 2002 is changed into the state where the atmosphere of ordinary temperature **(ed) and the air of the vehicle interior of a room of an automobile is made to ** by the fan who is not illustrating by the evaporator 2004, heat will be taken by the atmosphere of ordinary temperature, and temperature will fall and liquefy the refrigerant of the shape of gas in the elevated temperature in a condenser 2002.
[0136] Then, if this liquefied refrigerant passes an expansion valve 2003 and is supplied to an evaporator 2004, since it is in a low voltage state here, the refrigerant of a liquid will take the evaporation latent heat from the air of the vehicle interior of a room, and will carry out evaporation boil rapidly, it will gasify, and temperature will fall rapidly here.
[0137] Since the refrigerant gasified within the evaporator 2004 is inhaled by the compressor 2001 one after another at this time, the air of the vehicle interior of a room by which there is no inside of an evaporator 2004 in high pressure with a bird clapper, and the evaporation which the refrigerant followed is maintained, consequently the condenser 2002 is **(ed) will be cooled, and the work as an air-conditioner will be obtained.
[0138] then, the path of the refrigerant from an evaporator 2004 to [with the operation gestalt of this drawing 21 , applies any of the semiconductor module by the operation gestalt of this invention described above for this air-conditioner they are, and] a compressor 2001 -- the conductor of a semiconductor module -- it constitutes so that a series of fluid channels for cooling which pass along a member 103 may be contained
[0139] Here, it is the almost same temperature as the air of the vehicle interior of a room currently cooled by the air-conditioner, the refrigerant of the shape of gas which comes out from an evaporator 2004 is in remarkable low temperature rather than ordinary temperature, therefore according to this operation gestalt, it can cool the power semiconductor device 103 still more effectively.
[0140] next, drawing 22 -- the operation gestalt of drawing 21 -- setting -- the conductor of a semiconductor module -- the branch line 2006 which equipped with the control valve 2005 a series of fluid channels for cooling which pass along a member 103 is formed Therefore, since there is a control valve 2005 in the case of this operation gestalt, according to the operating condition of a semiconductor module, the flow rate of the refrigerant by which conduction is carried out there is changeable.
[0141] When the power semiconductor module by the above-mentioned operation gestalt is applied to an automobile, a starter generator is in the target load. The hybrid car of the method it runs with a motor at the time of start is equipped with this starter generator, and short time duty of the power semiconductor module applied to the control is carried out at the time of start.
[0142] that is, -- the time of generation of heat of a power semiconductor module being a short time, therefore a power semiconductor device generating heat in this case, according to the operation gestalt of drawing 22 -- control valve 2005 ** -- opening -- the refrigerant of an air-conditioner -- a conductor -- a power semiconductor device can be effectively cooled by circulating a member 103

[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the plan showing one outline of the semiconductor module by this invention.
[Drawing 2] It is the front view showing one outline of the semiconductor module by this invention.
[Drawing 3] It is the plan showing the 1st operation gestalt of the semiconductor module by this invention.
[Drawing 4] It is the cross section showing the 1st horizontal operation gestalt of the semiconductor module by this invention.
[Drawing 5] It is the cross section showing the 1st vertical operation gestalt of the semiconductor module by this invention.
[Drawing 6] It is the equal circuit of the 1st operation gestalt of the semiconductor module by this invention.
[Drawing 7] It is explanatory drawing of the piping connection method of the 1st operation gestalt of the semiconductor module by this invention.
[Drawing 8] It is explanatory drawing of the piping connection method of the 1st operation gestalt of the semiconductor module by this invention.
[Drawing 9] It is explanatory drawing of the piping connection method of the 1st operation gestalt of the semiconductor module by this invention.
[Drawing 10] the conductor in the operation gestalt of this invention -- it is explanatory drawing showing an example of a member
[Drawing 11] It is explanatory drawing of the modification in the 1st operation gestalt of the semiconductor module by this invention.
[Drawing 12] It is explanatory drawing of the joint in the 1st operation gestalt of the semiconductor module by this invention.
[Drawing 13] It is expansion explanatory drawing of the joint in the 1st operation gestalt of the semiconductor module by this invention.
[Drawing 14] It is the plan showing the 2nd operation gestalt of the semiconductor module by this invention.
[Drawing 15] It is the cross section showing the 2nd operation gestalt of the semiconductor module by this invention.
[Drawing 16] It is the cross section showing the 2nd operation gestalt of the semiconductor module by this invention.
[Drawing 17] It is the plan showing the piping connection method of the 2nd operation gestalt of the semiconductor module by this invention.
[Drawing 18] It is the plan showing the 3rd operation gestalt of the semiconductor module by this invention.
[Drawing 19] It is the cross section showing the 3rd operation gestalt of the semiconductor module by this invention.
[Drawing 20] It is the cross section showing the 4th operation gestalt of the semiconductor module by this invention.
[Drawing 21] It is the block diagram showing the 5th operation gestalt of the semiconductor

module by this invention.
[Drawing 22] It is the block diagram showing the 5th operation gestalt of the semiconductor module by this invention.
[Drawing 23] It is the cross section showing the 1st example of the semiconductor module by the conventional technology.
[Drawing 24] It is the cross section showing the 2nd example of the semiconductor module by the conventional technology.
[Drawing 25] It is the cross section showing the 3rd example of the semiconductor module by the conventional technology.
[Drawing 26] It is the cross section showing the 4th example of the semiconductor module by the conventional technology.
[Description of Notations]
101 Base Board
102 Resin Insulating Layer
103 Conductor -- Member
104 Power Semiconductor Device
105 105a Insulating piping
105b Piping (conductor)
106 Circulation Way
107 Soldered Joint Layer
301 Resin (for Closure)
302 External End-Connection Child
303 Case
304 Metal Thin Line
305 Circuit Pattern
306 Conductive Layer
307 Printed Circuit Board
308 Internal Connection Terminal
401 Insulating Layer
1001 Stress Impingement Baffle
1701 Power Semiconductor Device for Auxiliary Machinery
1702 1st Printed Circuit Board (Conductive Layer Which Carries Power Semiconductor Device for Auxiliary Machinery)
1703 2nd Printed Circuit Board
1801 Pump
1802 Heat Exchanger
1803 Fan
1804 Cooling Water
1805 Cooling Wind
2001 Compressor
2002 Condenser
2003 Expansion Valve
2004 Evaporator
2005 Control Valve
2006 Branch Line
2101 Ceramic Substrate
2102 Circuit Pattern
2103 Mounting Bolt
2104 Water-cooled Fin
2105 Grease
2201 Air-Cooling Fin

[Translation done.]

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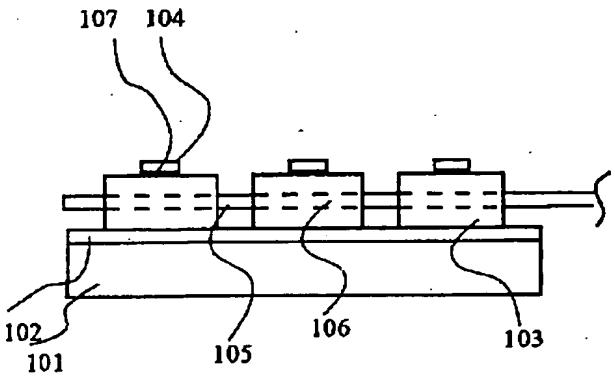
最終頁に続く

(54)【発明の名称】半導体モジュール及び電力変換装置

(57)【要約】
【課題】　冷却能力が高く、且つ、製造時、運転時の熱応力による絶縁破壊の虞のない、高信頼性の半導体モジュールと、それを用いた電力変換装置を提供すること。
【解決手段】　ベース板１０１に、樹脂絶縁層１０２を介して、内部に流通路１０６を有する導体部材１０３を接合させ、この導体部材１０３を回路パターンの導体として、これにパワー半導体素子１０４を半田接合する。そして、各導体部材１０３の流通路１０６を絶縁配管１０５で連結し、冷却水を流すようにしたもの。パワー半導体素子１０４と導体部材１０３の間には、半田接合層１０７があるだけなので、冷却能力が高く、且つ、製造時、運転時の熱応力による絶縁破壊の虞れがないので、高信頼性のパワー半導体モジュールが得られる。

図２



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【特許請求の範囲】

【請求項１】　ベース部材の表面に、絶縁層を介して形成した回路パターン用導体を備え、該回路パターン用導体の表面に半導体素子をろう付け接合する方式の半導体モジュールにおいて、

前記回路パターン用導体の、少なくとも前記半導体素子が接合される部分を、内部に流体の流通路となる孔が貫通されている導体部材で形成し、

前記半導体素子の放熱が、前記流通路に通流される流体により与えられるように構成したことを特徴とする半導体モジュール。

【請求項２】　請求項１に記載の発明において、

前記流通路を有する導体部材が２個以上で、これら導体部材の中の少なくとも２個については、それらの流通路の出口と入口が同一直線上に位置するようにして、前記ベース部材に配置されていることを特徴とする半導体モジュール。

【請求項３】　請求項１に記載の発明において、

前記流通路に通流される流体を冷却する熱交換装置からなる循環系統と、

前記循環系統に冷媒を流すポンプと、

前記ポンプを駆動する電気回路を備え、

前記電気回路は、前記ベース部材に設置されていることを特徴とする半導体モジュール。

【請求項４】　請求項３に記載の発明において、

前記熱交換装置が風冷式であり、その冷却風により前記ベース部材が冷却されるように構成したことを特徴とする半導体モジュール。

【請求項５】　請求項３に記載の発明において、

前記ベース部材が内部に流通路を有し、

該流通路に、前記熱交換装置で冷却された流体が通流されるように構成したことを特徴とした半導体モジュール。

【請求項６】　請求項１に記載の発明において、

前記流通路を有する導体部材の当該流通路に対する前記流体の通流が、絶縁配管を介して行なわれ、

この絶縁配管の融点が、前記ろう付け接合に使用されるろう材の融点よりも高くなるように構成されていることを特徴とする半導体モジュール。

【請求項７】　請求項１に記載の発明において、

前記流体が、別途設置されているエアコン装置から分岐された冷媒であることを特徴とする半導体モジュール。

【請求項８】　請求項１乃至請求項７のいずれかに記載の半導体モジュールを主回路のスイッチング素子として用いたことを特徴とする電力変換装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、ベース部材の表面に、絶縁層を介して形成した回路パターン用導体部材を備え、該回路パターン用導体部材の表面に半導体チップ

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をろう付け接合する方式の半導体モジュールに係り、特に電力変換用スイッチング素子に好適なパワー半導体モジュールと、それを用いた電力変換装置に関する。

【０００２】

【従来の技術】スイッチング素子を内蔵したパワー半導体モジュールや、これに制御回路を内蔵したＩＰＭ(Intelligent Power Module)は、近年、自動車や鉄道車両など高信頼性が要求される分野で大きく用途が拡がり、この結果、信頼性の向上が特に要求されている。

【０００３】そして、このとき、ＩＧＢＴ(絶縁ゲートバイポーラトランジスタ)などのスイッチング素子も大容量化され、これに伴い、半導体素子(半導体チップ)の発熱量が多くなるので、冷却能力の向上が強く要求されるようになっている。また、近年、ハイブリッド自動車の実用化が進んでいるが、ここで、発進時、主としてモータ(電動機)により走行する方式のハイブリッド自動車の場合、パワー半導体素子は発進毎に短時間だけ大きく発熱する。

【０００４】従って、この様な用途では、パワー半導体素子の接合温度の最大値は低いが、パワー半導体素子の発熱変化幅が大きくなり、この結果、熱膨張と熱収縮による応力変化、いわゆる熱揺動も大きくなり、且つ、その回数も多くなる。そして、この熱揺動は、特に半田などによるろう付接合部に熱疲労を与えるので、高信頼性の付与と保持には、効果的な冷却が必要になる。

【０００５】ところで、このようなパワー半導体モジュールやＩＰＭでは、搭載されているパワー半導体素子の発熱量の多さを考慮し、通常、高熱伝導性の金属などからなるベースと、高熱伝導性で且つ高電気絶縁性の材料からなる絶縁基板と、回路パターンが形成された導電層とで構成されるのが一般的であり、このとき、搭載部品の発熱量に応じて絶縁基板の材料が選択されるのが通例である。

【０００６】そして、発熱量が大きな中容量から大容量の製品では、絶縁基板として、高価ではあるが、熱伝導率の大きいアルミナセラミックス、窒化アルミニウムセラミックスなどのセラミックスが主として用いられている。ここで、図２３と図２４に、従来技術によるパワー半導体モジュールの一例を示す。

【０００７】このモジュールは、図示のように、例えば銅などのベース板１０１の一方の面(図では上側の面)に、絶縁基板となるセラミック板２１０１を張り合わせ、このセラミック板２１０１に形成してある回路パターン２１０２ａ上に、半田付接合されたパワー半導体素子１０４を設けたものである。このとき、セラミック板２１０１は、裏面の銅パターン２１０２ｂを用いてベース板１０１に半田付接合されている。

【０００８】そして、この回路パターン２１０２ａに金属線３０４による接続が施され、更にパワー用外部接続端子３０２ａと信号用外部接続端子３０２ｂに対する配

線が施された上でケース３０３内に納められ、樹脂３０１により封止される。なお、ここで、樹脂とは合成樹脂、いわゆるプラスチックのことである。

【０００９】次に、ベース板１０１は、グリース２１０５を介在させて、冷却部材に取り付けられるが、ここで、図２３は、水冷式の冷却部材２１０４に取り付けた場合で、図２４はフィンを有する空冷式の冷却部材２２０１に取り付けた場合であり、このとき、いずれも取付ボルト２１０３により冷却部材に固定される。

【００１０】ところで、パワー半導体モジュールは、線膨張係数が異なる種々の材料が用いられているので、ベース板１０１に反りがあるのが一般的である。ここで、この反りの方向は、部品及び製造工程により、ベース板１０１の冷却部材に対する接合面の中央が窪んでいる凹方向と、接合面の中央が膨らんでいる凸方向の双方の場合がある。

【００１１】反りが凹方向の場合、ベースと冷却部材間にあるグリース２１０５の層厚が増してしまうので、ベースと冷却部材間の接触熱抵抗が大きくなり、冷却能力が低下し、動作時、パワー半導体素子１０４の温度上昇が抑えられず、性能が低下し破壊してしまう虞れもあり、また、熱揺動も大きくなるので、半田接合層１０７などによる接合部の寿命が低下してしまう。

【００１２】一方、反りが凸方向の場合、取付用のボルト２１０３を締め付けた際に、セラミック基板２１０１に大きな曲げモーメントが現われ、しばしば割れが生じてしまう。ここで、割れが生じたセラミック基板２１０１は、絶縁耐量が失われてしまうので、このような半導体モジュールは使用不能になってしまう。

【００１３】このように、セラミック基板２１０１は高熱伝導で高絶縁であるが、脆く割れ易く、従って、図２３と図２４に示すセラミック基板２１０１を用いたパワー半導体モジュールは、冷却能力には特に問題はないが、セラミック基板２１０１の割れによる絶縁破壊という致命的な不良を生じる危険性があり、取付けに際しては細心の注意が必要である。

【００１４】一方、発熱量が比較的少ない小容量のパワー半導体モジュールでは、絶縁基板として、熱伝導率はあまり高くないが、かなり安価な樹脂製の絶縁層が用いられている。図２５は、従来技術による小容量パワー半導体モジュールの一例で、この場合絶縁基板の代りに樹脂絶縁層１０２が用いられている。

【００１５】そして、この樹脂絶縁層１０２に回路パターンとなる導電層３０６を設け、この導電層３０６上にパワー半導体素子１０４が半田接合されているものであり、その他の構成は、図２４の場合と同じである。ところで、この樹脂絶縁層１０２を用いた場合も、セラミック基板２１０１を用いた場合と同様に反りが生じる。

【００１６】ここで、反りが凹方向の場合は、同様に接触熱抵抗が増大し、冷却能力が低下する。一方、反りが

凸方向の場合、樹脂絶縁層１０２は、セラミック基板２１０１と比較して縦弾性係数が小さく延びが大きいので、割れる虞はない。

【００１７】以上の様に、樹脂絶縁層１０２は縦弾性係数が小さく、延びも大きいが、熱伝導率が小さく、従って、この図２５の樹脂絶縁板１０２を用いたパワー半導体モジュールは、取付けの際に絶縁基板が割れる虞れはないが、冷却能力に問題がある。

【００１８】ところで、以上の半導体モジュールでは、いずれもグリース２１０５が用いられている。ここで、このグリース２１０５は、シリコン樹脂とセラッミク粉末の複合材料なので、熱伝導率はあまり高くない。

【００１９】このため、無いよりは数段優れてはいるものの、このグリース２１０５があるため、ベースと冷却部材間の熱抵抗が、パワー半導体素子１０４と冷却部材の間の熱抵抗の数割程度までを占めてしまうことになり、従って、この間の接触熱抵抗が低減できれば、冷却能力の向上に大きく寄与できることになる。

【００２０】そこで、この接触熱抵抗による冷却能力の低下と、絶縁基板の割れによる絶縁破壊の対策として、図２６に示すパワー半導体モジュールがある。この図２６に示すモジュールは、セラミック基板２１０１を直接、ろう付により冷却部材２２０１に接合したものであり、従って、例えば図２４に示した半導体モジュールにおけるベース板１０１と冷却部材２２０１間の接合部は、最初から存在しない。

【００２１】従って、このモジュールの場合、勿論、接合部に介在すべきグリースの層も無く、接触熱抵抗は本質的に存在しないので、冷却能力は飛躍的に向上する。また、この結果、ベース板１０１のねじ締めによる取付けも無いので、締め付けによる割れが発生する虞れも少ない。

【００２２】しかも、このとき、冷却部材２２０１をＡｌ－ＳｉＣなどの線膨張係数の小さい材料で構成することにより、セラミック基板２１０１との接合時の温度変化による残留応力と、運転時での熱応力が低減され、この結果、セラミック基板２１０１に発生する割れの虞れを更に小さく抑えることができる。

【００２３】

【発明が解決しようとする課題】上記従来技術は、半導体素子の冷却能力向上に限度がある点に配慮がされておらず、半導体モジュールの大容量化と高信頼性の保持に問題があった。まず、図２３乃至図２５に示した従来技術は、上記したように、絶縁基板の割れの問題があり、高信頼性が要求される用途への適用に不安があった。

【００２４】また、これらの従来技術は、取付けにも細心の注意が必要であり、更に、グリースが低熱伝導であるため、これを用いてもフィンとベース間の接触熱抵抗を小さく抑えるのが困難で、冷却能力の向上に問題があった。

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【００２５】一方、図２６に示した従来技術では、上記したように、冷却部材に線膨張係数の小さい材料を用いることにより、セラミック基板接合時の温度変化による残留応力と運転時での熱応力が低減でき、この結果、セラミック基板が割れる虞れは少ない。

【００２６】しかし、セラミックスは本質的に脆い材料であるから、大容量化によりセラミック基板の面積が大きくなった場合には、熱応力も大きくなるので、絶縁基板が割れる虞がある。また、自動車など、振動が厳しい用途に適用した場合には、セラミック基板に割れが生じてしまう虞れがあり、セラミック基板を用いた場合、パワー半導体モジュールの取り扱いには細心の注意が必要で、保守に際しても充分な注意を払う必要がある。

【００２７】本発明の目的は、冷却能力に優れ、絶縁基板の割れによる絶縁破壊の危険性の小さい、高信頼性のパワー半導体モジュール及びそれを用いた電力変換装置を提供することにある。

【００２８】

【課題を解決するための手段】上記目的は、ベース部材の表面に、絶縁層を介して形成した回路パターン用導体を備え、該回路パターン用導体の表面に半導体素子をろう付け接合する方式の半導体モジュールにおいて、前記回路パターン用導体の、少なくとも前記半導体素子が接合される部分を、内部に流体の流通路となる孔が貫通されている導体部材で形成し、前記半導体素子の放熱が、前記流通路に通流される流体により与えられるようにして達成される。

【００２９】このとき、前記流通路を有する導体部材が２個以上で、これら導体部材の中の少なくとも２個については、それらの流通路の出口と入口が同一直線上に位置するようにして、前記ベース部材に配置されていてもよく、前記流通路に通流される流体を冷却する熱交換装置からなる循環系統と、前記循環系統に冷媒を流すポンプと、前記ポンプを駆動する電気回路を備え、前記電気回路が、前記ベース部材に設置されているようにしてもよい。

【００３０】また、このとき、前記熱交換装置が風冷式であり、その冷却風により前記ベース部材が冷却されるようにしてもよく、或いは、前記ベース部材が内部に流通路を有し、該流通路に、前記熱交換装置で冷却された流体が通流されるようにしてもよい。

【００３１】更には、前記流通路を有する導体部材の当該流通路に対する前記流体の通流が絶縁配管を介して行なわれ、この絶縁配管の融点が、前記ろう付け接合に使用されるろう材の融点よりも高くなるように構成してもよく、前記流体が、別途設置されているエアコン装置から分岐された冷媒であるようにしてもよい。

【００３２】同じく上記目的は、前記いずれかに記載の半導体モジュールを主回路のスイッチング素子として用い、電力変換装置を構成することによっても達成される。

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【００３３】

【発明の実施の形態】まず、本発明の実施の形態について具体的に説明する前に、ここで、この実施形態の基本的な構成について、図１の平面図と図２の側面図により、簡単に説明する。これら図１と図２において、まず、１０１はベース板で、このベース板１０１の一方の面に樹脂絶縁層１０２が設けてある。次に、１０３は導体部材で、図示のように、幾つかの部分に分かれていて、これにより、半導体素子が接合される回路パターン導体を形成するようになっている。

【００３４】そして、各導体部材１０３は、樹脂絶縁層１０２を介して、ベース板１０１の上に配列され、樹脂絶縁層１０２によりベース板１０１に接合されていて、これら各導体部材１０３の露出面に、各々のパワー半導体素子１０４が半田接合層１０７により接合されている。

【００３５】ここで、各導体部材１０３は、例えば銅などの導電材料で作られ、図２に表わされているように、所定の厚さを持ち、その内部に、夫々厚み方向と直角に、冷却用流体の通路となる孔が、往復２本の流通路１０６として形成してある。

【００３６】そして、これらの流通路１０６は、絶縁材で作られている配管、つまり絶縁配管１０５により相互に連通され、各導体部材１０３の往復２本の流通路１０６を通って、一連の冷却用流体通路が折り返えされた経路として形成されるように作られている。

【００３７】そこで、配管１０５を介して、各導体部材１０３の流通路１０６に、所定の冷却材となる流体、例えば所定の温度の水を通流させてやれば、各導体部材１０３は、それぞれに接合されている各々のパワー半導体素子１０４に対する回路パターン導体を形成すると共に、各パワー半導体素子１０４を冷却する部材としても働くことになる。

【００３８】ここで、これら図１と図２の構成によれば、各導体部材１０３とパワー半導体素子１０４間の伝熱経路には、半田接合層１０７が介在しているだけであり、絶縁物は一切ないから、流通路１０６内の冷却水とパワー半導体素子１０４の間の熱抵抗は極めて小さく、従来の絶縁基板が介在していた場合と比較して大幅に低減されているので、高い冷却性能が容易に得られる。

【００３９】また、このとき、配管１０５が絶縁配管にしてあるので、異った電位にある各導体部材１０３の間で必要とする絶縁が容易に得られ、導体部材１０３による回路パターンの形成も容易になる。また、このとき、各導体部材１０３は、ベース板１０１上に複数個並べて配置される。

【００４０】そこで、各導体部材１０３の流通路１０６の入口と出口は、同一直線上に配置する。これにより、各流通路１０６の入口と出口が直線上に向き合って配置

させることができ、容易に配管の接続ができ、簡潔な配管が形成できる。

【００４１】ところで、各導体部材１０３は、その中に流通路１０６が形成されるので、一般の回路パターンにおける導体層に比して遥かに厚くする必要がある。ここで、この導体部材１０３の厚みが増すと、ベース板１０１との線膨張係数の差により、加工時及び運転時に発生する熱応力が大きくなる。

【００４２】しかし、ここでは、樹脂絶縁層１０２に、縦弾性係数が小さく、延びが大きい材料を適用することにより、厚さが大きな導体部材１０３をベース板１０１に接合しても、熱応力による樹脂絶縁層１０２に割れや、割れによる絶縁低下を招く虞れがない。

【００４３】このとき、パワー半導体素子１０４の放熱は、導体部材１０３の流通路１０６内を流れる冷却水の熱伝達によるので、樹脂絶縁層１０２の熱伝導の値は全く問題にならないから、上記したように、割れの発生が起こらない材質が任意に選べることになる。

【００４４】次に、本発明によるパワー半導体モジュールについて、図示の実施の形態により、具体的に説明する。ただし、本発明は、以下に説明する実施の形態に限られるものではない。

【００４５】まず、図３、図４、図５は、本発明を３相パワー回路を含むパワー半導体モジュールに適用した場合の一実施の形態で、ここで、図３は平面構造を表わし、図４は、図３のＡ－Ａ断面を、そして、図５は、図３のＢ－Ｂ‘断面を表わす。

【００４６】また、図６は、この３相パワー回路の等価回路で、各端子部分の符号は、図３の端子における符号と同じである。なお、この等価回路は、例えば３相のインバータとして使用されるものである。

【００４７】これらの図において、この実施形態によるパワー半導体モジュールは、ベース板１０１の一方の面(図４では上側になっている方の面)に絶縁基板となる樹脂絶縁層１０２を設け、その上に流通路１０６を有する導体部材１０３と、他の回路パターンとなる導電層３０６を接合し、この導体部材１０３上の所定の位置にパワー半導体素子１０４を、半田接合層１０７により接合させたものである。

【００４８】そして、各導体部材１０３の流通路１０６は、相互に絶縁配管１０５ａにより連通され、外部に引き出されている。また、各導体部材１０３上には、絶縁層４０１を介して、別の回路パターン３０５が、接合されている。

【００４９】更に、パワー半導体素子１０４と導体部材１０３、回路パターン３０５、それに導電層３０６は、それぞれ金属細線３０４により接続されている(図４では省略されている)。ここで、これらの金属細線３０４には、３００～５００μｍφ程度のアルミニウム合金のワイヤが用いられている。

【００５０】また、導体部材１０３、回路パターン３０５、及び導電層３０６には、適宜、内部接続端子３０８と外部接続端子３０２が設けてあり、内部接続端子３０８にはプリント基板３０７が接続されていて(図３にはプリント基板３０７の外形のみ破線で示している)、更に、このリント基板３０７には外部接続端子３０２ｂが適宜設けられている。

【００５１】ここで、この実施形態では、ケース３０３が樹脂絶縁層１０２を介してベース板１０１に接着されている(図３にはケースの外形のみ破線で示している)が、このとき、ケース３０３の材料として、耐熱性を有するＰＰＳ(ポリフェニレンサルファイド)樹脂を用いることにより、パワー半導体素子１０４と導体部材１０３の半田による接合と同時に、ケース３０３を樹脂絶縁層１０２に接着することができる。

【００５２】そして、これら導体部材１０３、絶縁配管１０５の一部、導電層３０５、回路パターン３０５、パワー半導体素子１０４、金属細線３０４、内部配線３０８、それに外部接続端子３０２の一部は、熱伝導率の高い樹脂３０１によって封止され、パワー半導体モジュールとして完成される。

【００５３】このとき、この封止用の樹脂３０１には、エポキシ樹脂などの比較的硬い熱硬化性樹脂を使用するのが一般的であるが、封止の際や、使用時に封止樹脂が金属細線や素子に悪影響を与えることを防止するために、シリコンゲルなどの比較的柔らかい材料を用いるようにしてもよい。

【００５４】更に具体的に説明すると、まず、ベース板１０１は、軽量で安価なアルミニウム若しくはアルミニウム合金で作られている。これは、このベース板１０１が、パワー半導体モジュール内で比較的大きな体積を有するので、銅と比較して、安価で軽量にできるアルミニウムがパワー半導体モジュールを作製するのに適しているからである。

【００５５】一方、冷却性能が重視される場合は、更に熱伝導率の高い銅を用いる。このとき、ベース板１０１は、内部での熱の広がりによる熱抵抗の低減が充分に得られるように、少なくとも２ｍｍの厚さにしてあり、３０ｍｍ程度の厚さにすることもある。ここで、このベース板１０１に、更に強制空冷用のフィン、又は水冷用の水冷管を設けても良い。

【００５６】次に、絶縁基板となる樹脂絶縁層１０２には、高絶縁性が要求されるので、このため、フィラーが分散されたエポキシ樹脂を用いるようになっている。なお、これにより低熱抵抗性も与えられる。

【００５７】そして、このフィラーが分散されたエポキシ樹脂による樹脂絶縁層１０２は、セラミック板と比較して縦弾性率が小さく、延びが大きいので、接合時と運転時の熱応力によっても、割れる虞れがない。

【００５８】ここで、フィラーには、例えば酸化珪素、

酸化アルミニウムなどの高熱伝導性の無機化合物で作られたものを用いればよく、このとき、フィラーの含有率を増すほど、樹脂絶縁層１０２の熱抵抗が低減できる。

【００５９】しかし、エポキシ樹脂中に分散可能なフィラー量には限界があるので、通常はフィラーの含有率を７５～９５％の範囲にすると良く、この場合、樹脂絶縁層１０２の熱伝導率は２～５Ｗ／ｍＫの範囲となる。

【００６０】一方、樹脂絶縁層１０２の熱抵抗を低減するのに有効な別の方法は、それを薄くすることである。しかし、樹脂絶縁層１０２を薄くすると、その分、絶縁耐圧が低下してしまう上、樹脂絶縁層にピンホールなどが発生し易くなって、信頼性が低下する虞れがあり、従って、樹脂絶縁層１０２の厚さの下限には限界があり、要求される絶縁耐圧にもよるが、５０～２５０μｍ程度が下限になる。

【００６１】ここで、本発明の場合、この樹脂絶縁層については、熱抵抗の低減よりも、加工時及び運転時の熱応力の緩和が要求されるので、従来のパワー半導体モジュールの場合よりも厚めの方がよい。

【００６２】また、この樹脂絶縁層１０２は、導体部材１０３及び導電層３０６をベース板１０１から絶縁するものであるから、これらの周囲にも絶縁耐圧に相当する沿面距離が必要であり、このため、足りない分は、ベース板１０１の表面を絶縁層で覆うことで補う必要がある。

【００６３】そこで、この実施形態では、図示のように、この樹脂絶縁層１０２をベース板１０１の導体部材１０３側の全面に設けてある。次に、導体部材１０３の材料としては、熱伝導を優先する場合は、銅若しくはアルミニウムの合金が選択される。

【００６４】このとき、アルミニウムは軽量であるという利点があるが、線膨張係数が大きいので、パワー半導体素子１０４を接合する半田接合層１０７の信頼性に問題があり、高信頼性を要求される用途には向かない。一方、銅はアルミニウムと比較して、低熱膨張性且つ高熱伝導性であり、従って、導体部材１０３に適している。

【００６５】また、パワー半導体素子１０４と導体部材１０３を接合する半田接合層１０７の信頼性を考慮する場合は、導体部材１０３として、線膨張係数がパワー半導体素子１０４を形成するシリコンに比較的近く、且つ、熱伝導率が高い材料を選択する。

【００６６】このとき該当する材料としては、モリブデン、アルミニウム・シリコンカーバイド(Ａｌ－ＳｉＣ)、銅と銅酸化物の複合材料などがあるが、この導体部材１０３には流通路１０６を設ける必要があるので、加工性を考慮し、銅と銅酸化物の複合材料が最適であるといえる。

【００６７】この銅と銅酸化物の複合材料は、銅と銅酸化物の比率により、線膨張係数、熱伝導率を変えることができ、ここで銅酸化物の比率が３０％のとき、線膨張係数が１３．５×１０$^{-6}$／Ｋで、熱伝導率が２４０Ｗ/ｍＫとなり、これが導体部材１０３に適している。

【００６８】次に、各導体部材１０３は流通路１０６の入口と出口が直線上にあるようにする。入口と出口が直線上にあるようにすると、同一部品で構成でき、容易に配管接続できるという利点がある。

【００６９】ここで、図３の実施形態では、１個の導体部材１０３ａの他に、同一形状の導体部材１０３ｂが３個並んで配置されているが、このとき、図示のように、入口と出口が直線上に並んでいると、同一部品を並べて配置した場合、それぞれの入口と出口をそのまま配管接続できる。

【００７０】次に、このときの配管接続方法について説明する。図３の実施形態では、配管接続した後で導電層３０６及び導体部材１０３を樹脂絶縁層１０２に接合するようになっており、このときの配管接続の手順を図７から図９により説明する。

【００７１】これらの図は配管接続順序を示したもので、矢印方向に配管１０５と導体部材１０３を移動させることにより、配管の接続を行なう。ここで、効率的な組立てのためには、各導体部材１０３ｂにおける流通路１０６の入口と出口が直線上にあることと、配管接続方向の反対側に十分なスペースを設けることが要件となり、更に、配管経路が図示のように、一筆書きになるようにするとよい。

【００７２】ところで、各導体部材１０３は回路パターンを形成する導体であり、図６に示す回路の一部の配線になっているので、導体部材１０３同士が異なる電位となる場合があり、この場合、導体部材１０３の流通路１０６をつなぐのに絶縁配管を使用する必要がある。

【００７３】図３の実施形態では、導電部材１０３がそれぞれ電位を異にするので、絶縁配管１０５ａにより配管している。しかし、同電位になる導体部材同士の配管は絶縁配管である必要はない。ここで、図３の配管１０５ｂは絶縁配管でない。

【００７４】一方、外部にある冷却水循環用のポンプに接続する配管と、パワー半導体素子の発熱により温度上昇した水の冷却用熱交換器に接続する配管には、一部、絶縁配管１０５ａを設け、ポンプや熱交換器から絶縁されるようにする。

【００７５】ここで、絶縁配管１０５ａは、例えばテフロン(商品名)製とすれば良い。テフロンは高絶縁性である上、可撓性に富み容易に曲げられるので、配管接続が容易になり、化学的にも安定しているので、高信頼性が得られる。

【００７６】次に、導体部材１０３に設ける流通路１０６は、導体部材１０３の熱抵抗が小さくなるように、パワー半導体素子１０４に近い部分に設ける。このとき、複数の流通路１０６を設けると、熱伝達面積が増すので冷却効率が向上する。

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【００７７】一方、熱伝達面積を増すためには、図１０(a)に示すように、流通路１０６を折り曲げて渦巻状にしても良く、同じく、図１０(b)に示すように、流通路１０６の内面にひれを設けるようにしても良い。

【００７８】次に、流通路１０６を設ける方法について説明する。まず、第一の方法は、ドリルなどの穿孔工具により、そのまま導体部材１０３に孔を開けて流通路１０６を形成する方法である。

【００７９】また、第二の方法は、予め導体部材１０３を、その厚み方向に分割された状態の２枚の部材としておき、双方の向かい合う面を切削加工で溝を形成する方法であり、この場合は、切削した面をろう付け等により貼り合わせることにより流通路１０６が得られる。

【００８０】ここで、第一の方法は、工程は少ないが、形状に制約があり、流通路の形状は直線になった単純なものに限られる。一方、第二の方法は、工程は多くなるが、図１０に示したように、曲がった複雑な形状や、複雑の断面の通路が作成可能である。ここで、上記した銅と銅酸化物の複合材料は、切削加工が可能なので、導体部材に向いている。

【００８１】次に、導電層３０６は、電気伝導を考慮して、銅若しくはアルミニウムの合金で作られ、樹脂絶縁層１０２の表面に張り合わせてある。ここで、アルミニウムは軽量、安価であると共に、前述のように、ベース板１０１と同じ材料であり、このため、加工時、樹脂絶縁層１０２に生じる熱応力が小さくなるので、導電層を構成する材料として適している。

【００８２】次に、導体部材１０３と導電層３０６を樹脂絶縁層１０２に接合する方法について説明すると、これは、樹脂絶縁層１０２上の所定の位置に接着材を塗布し、各々所定の位置に導体部材１０３と導電層３０６を載置した後、加熱、加圧することにより接合するのである。

【００８３】従って、ここで導体部材１０３と導電層３０６の厚さが概ね等しければ、加圧したとき、導体部材１０３及び導電層３０６と樹脂絶縁層１０２の接合面に均一な圧力が掛かるので、良好な接合を得ることができる。

【００８４】一方、回路パターン３０５は、絶縁層４０１を介して導体部材１０３に接合されているが、このときの絶縁層４０１の形成方法には、まず第一の方法として樹脂を用いる方法がある。この場合、シリコン樹脂系の接着剤を絶縁層４０１に用いることにより、回路パターン３０５の導体部材１０３に対する接合と絶縁が同時に達成できることになる。

【００８５】ここで、回路パターン３０５と、この回路パターンに適宜に設ける内部配線は抵抗が低く、運転時に生じる発熱は少ないから、それらについては冷却の必要はなく、従って、シリコン樹脂の低熱伝導性は問題とならない。

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【００８６】一方、接着剤塗布時の気泡などにより絶縁層４０１にピンホールが形成されていると、絶縁強度が落ちてしまうので、このときの接着剤は１００μmから６００μm程度の厚さに塗るのが望ましい。また、回路パターン３０５の接着は、パワー半導体素子１０４の半田接合のための加熱と同時に行なうとよい。

【００８７】絶縁層４０１の形成方法の第二は、セラミック基板を用いる方法で、この方法の場合、銀を表面と裏面に蒸着したアルミナ板を用いる。そして、まず、このアルミナ板の一方の面を、半田を介して導体部材１０３と導電層３０６に接合し、その他方の面に、回路パターン３０５を半田接合するのである。

【００８８】このとき使用する半田の融点は、導体部材１０３とパワー半導体素子１０４を接合する半田接合層１０７の融点と概ね同等とするのが望ましい。こうすることにより、パワー半導体素子１０４と導体部材１０３の半田接合と同時に、半田接合が得られるからである。

【００８９】パワー半導体素子１０４には、スイッチング素子としてＭＯＳＦＥＴ、又はＩＧＢＴを用いる。ここで、低耐圧の場合にはＭＯＳＦＥＴを用い、高耐圧が必要な場合にはＩＧＢＴを用いるといった選択が可能である。この実施形態は、図６から明らかなように、ＭＯＳＦＥＴが用いられており、ここで、フリーホイールダイオードには、ＭＯＳＦＥＴの寄生ダイオードを用いている。

【００９０】他方、スイッチング素子としてＩＧＢＴを用いる場合には、別途、ＩＧＢＴと逆並列接続したフリーホイールダイオードを搭載する。また、この実施形態は、ベアチップを実装した構成について示しているが、導体部材１０３上にトランスファーモールドされたディスクリートデバイスを実装しても、ベアチップの場合と同様に実施可能で、導体部材１０３により効果的に冷却される

次に、各導体部材１０３と導電層３０６には、図示のように、外部接続端子が適宜設けてある。ここで、まず、外部接続端子３０２ａは外部パワー回路に接続される。このため、この外部接続端子３０２ａは、ケース３０３に予めインサート形成しておき、パワー半導体素子１０４を導体部材１０３に半田付けするとき、及びケース３０３をベース板１０１に接着するとき、これと同時に、導体部材１０３と導電層３０６に半田接合するとよい。

【００９１】次に、回路パターン３０５には、内部接続端子３０８が適宜設けてある。このため、内部接続端子３０８は、プリント基板３０７に半田接合されるが、このプリント基板３０７には、パワー半導体素子１０４を駆動するドライバＩＣと、このドライバＩＣ及びパワー半導体素子で構成されるパワー回路を制御するマイコン、ゲート抵抗、サージ吸収用のコンデンサ等の電子部品を搭載してもよい。

【００９２】また、このプリント基板３０７には、更に

外部接続端子３０２ｂが適宜設けてあり、これにより、外部信号系回路に接続できるようになっている。ところで、上記実施形態において、導体部材１０３の表面に、半田濡れ性が良好な、例えばNi、Ag、Pt、Sn、Sb、Cu、Zn、Pd の群から選択された少なくとも１種の金属、又は、これらの群から選択された少なくとも２種の金属を含む合金を被覆するようにしてもよい。

【００９３】ここで、、上記した金属又は合金は、良好な半田濡れ性を備えているので、これらで導体部材１０３の表面を覆うことにより、パワー半導体素子１０４の半田付け性が大きく改善され、この結果、良好な接合が確実に得られることになり、より一層の信頼性向上を得ることができる。ここで、図３に示した実施形態では、導体部材１０３の表面をNi でメッキしたものである。

【００９４】次に、この実施形態において、上記した良好な半田濡れ性を備えている金属若しくは合金を導体部材１０３の表面に被覆する範囲について説明する。まず、本発明の実施形態としては、この被覆範囲は、導体部材１０３の全表面であっても良いが、一部でもよい。すなわち少なくとも一部であれば良い。

【００９５】ここで、まず、導体部材１０３の表面の一部に被覆したとすると、この場合、以下の効果が得られる。例えば、Ag など、半田濡れは良好だが、アルミニウムとの接合性が乏しい材料を用いる場合、一部にだけ被覆することにより、パワー半導体素子１０４の半田接合部ではAg メッキによる良好な半田接合が得られる。

【００９６】他方、アルミニウムの金属細線３０４が接続される部分にはAg メッキが無いので、パワー半導体素子１０４と金属細線３０４の双方共に良好な接合を得ることができる。次に、一部だけの被覆により、半田接合時でのパワー半導体素子１０４の位置ずれを抑えることができる。

【００９７】このとき、被覆した材料の半田濡れ性が良好な場合には、接合時に半田が溶融したとき、パワー半導体素子１０４が浮いて所定の位置から動いてしまうことがあるが、このとき、予め、パワー半導体素子１０４が半田接合される部分にのみ半田濡れ性が良好な材料で被覆しておけば、この部分の外には溶融した半田が流れ出さないので、パワー半導体１０４が動く虞れはなく、従って、所定の位置に半田接合することができるのである。

【００９８】この場合、半田のフィレット(流れ面)がパワー半導体素子１０４の周囲に綺麗に形成されるようにするためには、このときの半田の厚さ(後述)と同じか、数倍分程度、パワー半導体１０４の接合面より広い大きさの範囲を半田濡れが良好な材料で被覆すればよい。

【００９９】このときの半田接合層１０７の厚さとしては、半田接合部に発生する熱歪みの低減の見地から、５０μｍ以上になるようにするのが望ましい。従って、上記した被覆処理部がパワー半導体１０４の周囲からはみ出してしまう範囲は、５０μｍから数１００μｍ程度となる。

【０１００】このときのパワー半導体素子１０４と導電層１０３の接合に使用する半田接合層１０７の材質としては、プロセス温度が低い点からみると、６３％Sn－３７％Pb などの錫と鉛の共晶組成に近い合金が望ましいが、鉛を含有していない半田が要求される場合には、Ｓｎ-Ａｇ、Ｓｎ-Ａｇ-Ｃｕ、Ｓｎ－Ａｇ－Ｂｉ(ビスマス)系の半田を使用すればよい。

【０１０１】ここで、半田の選定の際、半田の接合時の最高温度を、前期絶縁配管の耐熱温度よりも低くすることにより、配管接続後の半田接合が可能となる。このとき、半田接合は、一般的に融点より５０℃程度高い温度で行なうので、半田の融点を、絶縁配管１０５の耐熱温度より５０℃以上低くするとよい。

【０１０２】一方、半田接合の最高温度を、絶縁配管１０５の耐熱温度より高くする必要がある場合には、半田接合の後で配管を接続してやれば良い。ここで、導体部材１０３を樹脂絶縁層１０２に接合する際は、前述のように、加圧を要する。従って、半田接合は、導体部材１０３を樹脂絶縁層１０２に接合する工程よりも後の工程となるので、半田接合後に配管接続する際には、導体部材１０３は既にベース板１０１上に固定されている。

【０１０３】このような場合には、図１１に示すように、導体部材１０３に形成してある流通路１０６の入口と出口が外側を向いている構成とすることにより、半田接合後での配管接続を可能にすることができる。

【０１０４】次に、パワー半導体素子１０４を導体部材１０３に接合するための半田接合層１０７について、図１２と図１３により説明する。ここで、図１３は、図１２のＡ部の拡大図であり、これらの図から明らかなように、この半田接合層１０７には、その層の間に応力緩衝板１００１が設けてある。

【０１０５】そこで、この応力緩衝板１００１の材料として、その線膨張係数の値が、パワー半導体素子１０４を構成するシリコンと導体部材１０３を構成する材料の間にある材料を用いることにより、半田接合層１０７に生じる熱ひずみを低減させることができる。

【０１０６】そして、このような応力緩衝板１００１の材料としては、比較的、線膨張係数が低いにもかかわらず、熱伝導率が高く、しかも半田濡れ性が良好なことから、ニッケル若しくはニッケル合金が適している。

【０１０７】このとき、半田接合層１０７に、予めこの半田接合層１０７の厚さと同等の直径のニッケルのボールを混入しておくことにより、応力緩衝板１００１が半田接合層１０７の層中で傾くのが防止でき、半田接合層１０７の層厚の均一性が保持されるので、更に高信頼性が得られる。

【０１０８】従って、以上に説明した実施形態によれば、冷却能力に優れ、絶縁基板の割れによる絶縁破壊の

危険性が少なく、高信頼性のパワー半導体モジュールを容易に得ることができる。また、この結果、この実施形態に係るパワー半導体モジュールを用いることにより、高信頼性の電力変換装置を容易に得ることができる。

【０１０９】次に、本発明の他の実施形態に係る半導体モジュールついて、図１４～図１７により説明する。このとき、図１４は平面構造を表わし、図１５は図１３のＡ－Ａ’断面、図１６は図１３のＢ－Ｂ’断面を表わす。一方、図１７は、図１４における配管接続方法を説明するため、導体部材１０３と配管１０５、流通路１０６、樹脂絶縁層１０２、それにパワー半導体素子１０４だけを抜き出して示したものである。

【０１１０】ここで、まず、これらの図１４～図１７に示した実施形態が、図３～図５で説明した実施形態と異なる点は、図１４と図３を比較すれば明らかなように、主として導体部材間の配管の接続形式にある。なお、その他の点では、ほとんど共通しているので、同じ構成については同じ符号を付すだけで、詳しい説明は割愛する。

【０１１１】すなわち、図３の実施形態では、各導体部材１０３の流通路１０６が、図では横方向になっていて、一連の冷却用流体通路の最後で折り返えされた経路として形成されているのに対して、この図１４の実施形態では、流通路１０６が縦方向になっていて、一連の冷却用流体通路が、各導体部材１０３を順次往復して通過して行く経路として形成されている。

【０１１２】また、この結果、これらの実施形態の間の大きな相違点は、一連の冷却用流体通路における絶縁配管１０５ａの適用個所にもある。つまり、外部との接続部に絶縁配管１０５ａが設けてある点は、図３の実施形態と同様であるが、この図１４の実施形態では、導体部材１０３間の配管については、絶縁配管１０５ａが長さの短い個所で、且つ曲がりの無い個所にだけに設けられているからである。

【０１１３】詳しく説明すると、この図１４の実施形態では、図１７を見れば更に明らかなように、絶縁配管１０５ａは、図で上側にある１個の導体部材１０３ｅと、下側にある３個の導体部材１０３ｆの間の直線部分にだけ設けられている。ここで、金属の配管と異なり、絶縁配管１０５ａには大きな曲率を設けない方が、絶縁劣化の虞れがない点で優れていることは言うまでもない。

【０１１４】そこで、この図１４～図１７に示した実施形態では、配管に曲がりが必要な個所については、配管の入口と出口が同電位となるように、導体部材１０３を配置し、これにより、導体部材１０３ｅと導体部材１０３ｆ間の配管にだけ絶縁配管１０５ａを用いれば済むようにしてある。

【０１１５】そして、この結果、導体部材１０３ｅ同仕と、導体部材１０３ｆ同士の配管には、成型が容易な金属など、導電材料の配管１０５ｂを用いることができ、

配管を曲げたことによる信頼性の低下が起こらないようにすることができる。

【０１１６】従って、この実施形態によれば、絶縁配管１０５ａは直線に限られ、絶縁配管１０５ａを曲げる必要がなく、従って、曲げによる絶縁配管の劣化の虞れは極めて少なく、高信頼性である。また、この結果、高価な絶縁配管１０５ａの使用量が少なくて済み、低価格化が図れることになる。

【０１１７】次に、この図１３の実施形態では、上記の配管配置を可能にするため、回路パターンとなる導電層３０６が絶縁層４０１を介して、導体部材１０３ｅの上に設けてあり、この点でも、図３の実施形態とは異なっている。

【０１１８】そして、この導電層３０６が導体部材１０３ｅ上に設けられた結果、導体部材１０３ｅと導体部材１０３ｆの間が空間になり、曲がりの無い管路で配管することができ、且つ配管距離が小さくなるので、絶縁配管１０５ａの寸法を短くすることができる。

【０１１９】このとき、この導体層３０６は、銅、アルミニウムなどの良導体で形成できるので、図３の実施形態における導電層３０６のように、厚さを大にする必要はない。しかも、この導電層３０６には、導体部材１０３ｅと対向する電流が流れるので、相対的にインダクタンスが低下される。

【０１２０】そして、このインダクタンスの低下により、パワー半導体素子１０４がオフしたときの電圧の跳ね上がりが小さくなり、過電圧によるパワー半導体素子１０４の破壊の虞れが少なくできる。

【０１２１】次に、図１８と図１９は、図３に示したパワー半導体モジュールに、熱交換器１８０２と冷却水循環用のポンプ１８０１、ファン１８０３、それに、これらポンプとファンなどからなる補機駆動用の電気回路を設けた場合の本発明の一実施形態で、図１８は平面構造を示し、図１９は、図１８のＡ－Ａ’断面を示したものである。

【０１２２】ここで、図３～図５で説明した実施形態と同じ構成については、同一の符号を付してあり、従って、これらの部分についての詳しい説明は割愛する。これら図１８と図１９において、補機を駆動する電気回路は、補機用のパワー半導体素子１７０１と、このパワー半導体素子１７０１を搭載するための導電層からなる第１のプリント基板１７０２、それに第２のプリント基板１７０３で構成されている。

【０１２３】そして、まずプリント基板１７０２は、導体部材１０３と同時に加熱、加圧により樹脂絶縁層１０２に接合してある。ここで、このプリント基板１７０２は、導体部材１０３より薄いが、厚さの差が生じる部分に治具等を挿入することにより、導体部材１０３と同一の面圧で接合させることができるようにする。

【０１２４】次に、第２のプリント基板１７０３も、プ

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リント基板１７０２と同時に樹脂絶縁層１０２に接合する。そして、この後、プリント基板１７０２にパワー半導体素子１７０１を半田接合するのであるが、このときの半田接合は、主機を駆動するパワー半導体素子１０４と同時に行なう。

【０１２５】第２のプリント基板１７０３には、補機の駆動を制御する回路と、その他の電子部品が搭載されるが、更に、主機の駆動を制御する回路と電子部品を搭載しても良い。そして、このプリント基板１７０３は、適宜、内部接続端子３０８を介してプリント基板３０７と電気的に接続される。

【０１２６】各導電部材１０３の流通路１０６は、絶縁配管１０５ａを介して熱交換器１８０２とポンプ１８０１に連接され、冷却水１８０４がポンプ１８０１により循環され、パワー半導体素子１０３で発生した熱により、温度が上昇した冷却水１８０４は、熱交換器１８０２の中で、ファン１８０３から供給される冷却風１８０５により強制空冷される。

【０１２７】このとき、ベース板１０１の下面にもファン１８０３から供給される冷却風１８０５を誘導させることにより、このベース板１０１からの放熱が促進されるようにする。これにより、プリント基板１７０２上に搭載してある補機用のパワー半導体素子１７０１と第２のプリント基板１７０３に搭載されている回路素子の冷却が図れることになる。

【０１２８】このとき、主機の駆動回路は流通路１０６を設けた導体部材１０３により冷却されるが、補機の駆動回路は、ベース板１０１下面からの熱伝達だけで放熱される。従って、第１のプリント基板１７０２と第２のプリント基板１７０３は、図示のように、冷却風１８０５の流れの上流側に位置するようにしてある。

【０１２９】但し、補機に対して主機の電力が大きく、主機の下部のベース下面の方が補機の下部のベース下面の温度より高いくなる場合には、主機の駆動回路が冷却風１８０５の風上になるように配置してもよい。

【０１３０】次に、図２０は、ベース板１０１も水冷式にした場合の本発明の一実施形態であり、このため、図示のように、ベース板１０１にも流通路１０６を設けると共に、ポンプ１８０１も２台設け、熱交換器１８０１で放熱された冷却水１８０４ｂが、ベース板１０１に設けた流通路１０６を循環するように構成してある。

【０１３１】従って、この図２０の実施形態によれば、補機用駆動回路の発熱量が多くなっても容易に対応して、常に効率よく冷却することができ、高信頼性が図れることになる。

【０１３２】次に、図２１は、本発明に係る半導体モジュールを、エアコン(エアコンデショナ：空気調和装置)が装備されている自動車の電子部品に適用した場合の一実施形態で、ここに示した自動車用のエアコンは、主要部が圧縮機２００１と凝縮器２００２、膨張弁２００３、それに蒸発器２００４で構成され、これらの内部と配管内には、例えば代替フロンなどの所定の冷媒が封入されている。

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【０１３３】圧縮機２００１は、図示してない自動車のエンジンで駆動され、これにより、圧縮機２００１は、蒸発器２００４からガス状の冷媒を吸入して圧縮し、温度が常温以上の高温に上昇したガス状の冷媒を凝縮器２００２に供給する動作を行ない、結果として、凝縮器２００２の内部は高温高圧状態になり、蒸発器２００４の内部は低圧状態になるように動作する。

【０１３４】このとき、膨張弁２００３は、液化された冷媒だけを通過させる働きをし、これにより、凝縮器２００２側での高圧状態と、蒸発器２００４側での低圧状態が破られないで保持されるようにする。

【０１３５】そこで、図示してないファンなどにより、凝縮器２００２を常温の大気に曝された状態にし、自動車の車室内の空気が蒸発器２００４に曝されるようにしておくと、凝縮器２００２の中の高温にあるガス状の冷媒は、常温の大気により熱を奪われて温度が低下し、液化する。

【０１３６】そこで、この液化した冷媒が膨張弁２００３を通過して蒸発器２００４に供給されると、ここは低圧状態にあるので、ここで液体の冷媒は、車室内の空気から気化潜熱を奪って急激に蒸発沸騰し、ガス化して急激に温度が低下する。

【０１３７】このとき、蒸発器２００４内でガス化した冷媒は、次々と圧縮機２００１に吸入されるので、蒸発器２００４内が高圧になることはなく、冷媒の連続した蒸発が維持され、この結果、凝縮器２００２が曝されている車室内の空気が冷され、エアコンとしての働きが得られることになる。

【０１３８】そこで、この図２１の実施形態では、このエアコンに上記した本発明の実施形態による半導体モジュールの何れかを適用し、蒸発器２００４から圧縮機２００１に至る冷媒の経路に、半導体モジュールの導体部材１０３を通る一連の冷却用流体通路が含まれるように構成したものである。

【０１３９】ここで、蒸発器２００４から出てくるガス状の冷媒は；エアコンにより冷されてる車室内の空気とほぼ同じ温度で、常温よりもかなり低温にあり、従って、この実施形態によれば、パワー半導体素子１０３を更に効果的に冷却することができる。

【０１４０】次に、図２２は、図２１の実施形態において、半導体モジュールの導体部材１０３を通る一連の冷却用流体通路に、制御弁２００５を備えた分岐配管２００６を設けたものである。従って、この実施形態の場合、制御弁２００５があるので、半導体モジュールの使用状況に応じて、そこに通流される冷媒の流量を変えることができる。

【０１４１】上記実施形態によるパワー半導体モジュー

ルを自動車に適用した場合、対象となる負荷にスタータジェネレータがある。このスタータジェネレータは、発進時に電動機で走行する方式のハイブリッド自動車に備えられているものであり、従って、その制御に適用したパワー半導体モジュールは、発進時に短時間使用される。

【０１４２】つまり、この場合、パワー半導体モジュールの発熱は短時間であり、従って、図２２の実施形態によれば、パワー半導体素子が発熱するときだけ制御弁２００５をを開き、エアコンの冷媒を導体部材１０３に循環させることにより、パワー半導体素子を効果的に冷却できる。

【０１４３】

【発明の効果】本発明によれば、冷却能力に優れ、絶縁基板の割れによる絶縁破壊の虞れが少なく、高信頼性のパワー半導体モジュールと、それを用いた電力変換装置を提供できる。

【図面の簡単な説明】

【図１】本発明による半導体モジュールの一概要を示す平面図である。

【図２】本発明による半導体モジュールの一概要を示す正面図である。

【図３】本発明による半導体モジュールの第１の実施形態を示す平面図である。

【図４】本発明による半導体モジュールの第１の横実施形態を示す断面図である。

【図５】本発明による半導体モジュールの第１の縦実施形態を示す断面図である。

【図６】本発明による半導体モジュールの第１実施形態の等価回路である。

【図７】本発明による半導体モジュールの第１の実施形態の配管接続方法の説明図である。

【図８】本発明による半導体モジュールの第１の実施形態の配管接続方法の説明図である。

【図９】本発明による半導体モジュールの第１の実施形態の配管接続方法の説明図である。

【図１０】本発明の実施形態における導体部材の一例を示す説明図である。

【図１１】本発明による半導体モジュールの第１の実施形態における変形例の説明図である。

【図１２】本発明による半導体モジュールの第１の実施形態における接合部の説明図である。

【図１３】本発明による半導体モジュールの第１の実施形態における接合部の拡大説明図である。

【図１４】本発明による半導体モジュールの第２の実施形態を示す平面図である。

【図１５】本発明による半導体モジュールの第２の実施形態を示す断面図である。

【図１６】本発明による半導体モジュールの第２の実施形態を示す断面図である。

【図１７】本発明による半導体モジュールの第２の実施形態の配管接続方法を示す平面図である。

【図１８】本発明による半導体モジュールの第３の実施形態を示す平面図である。

【図１９】本発明による半導体モジュールの第３の実施形態を示す断面図である。

【図２０】本発明による半導体モジュールの第４の実施形態を示す断面図である。

【図２１】本発明による半導体モジュールの第５の実施形態を示す構成図である。

【図２２】本発明による半導体モジュールの第５の実施形態を示す構成図である。

【図２３】従来技術による半導体モジュールの第１の例を示す断面図である。

【図２４】従来技術による半導体モジュールの第２の例を示す断面図である。

【図２５】従来技術による半導体モジュールの第３の例を示す断面図である。

【図２６】従来技術による半導体モジュールの第４の例を示す断面図である。

【符号の説明】

１０１　ベース板
１０２　樹脂絶縁層
１０３　導体部材
１０４　パワー半導体素子
１０５、１０５ａ　絶縁配管
１０５ｂ　配管(導体)
１０６　流通路
１０７　半田接合層
３０１　樹脂(封止用)
３０２　外部接続端子
３０３　ケース
３０４　金属細線
３０５　回路パターン
３０６　導電層
３０７　プリント基板
３０８　内部接続端子
４０１　絶縁層
１００１　応力緩衝板
１７０１　補機用パワー半導体素子
１７０２　第１のプリント基板(補機用パワー半導体素子を搭載する導電層)
１７０３　第２のプリント基板
１８０１　ポンプ
１８０２　熱交換器
１８０３　ファン
１８０４　冷却水
１８０５　冷却風
２００１　圧縮機
２００２　凝縮器

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２００３　膨張弁
２００４　蒸発器
２００５　制御弁
２００６　分岐配管
２１０１　セラミック基板

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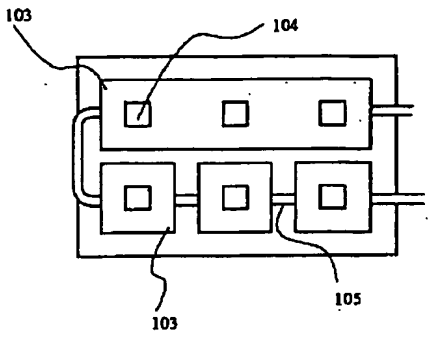
２１０２　回路パターン
２１０３　取付ボルト
２１０４　水冷フィン
２１０５　グリース
２２０１　空冷フィン

【図１】

図1



【図２】

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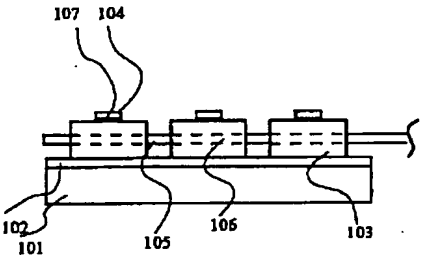

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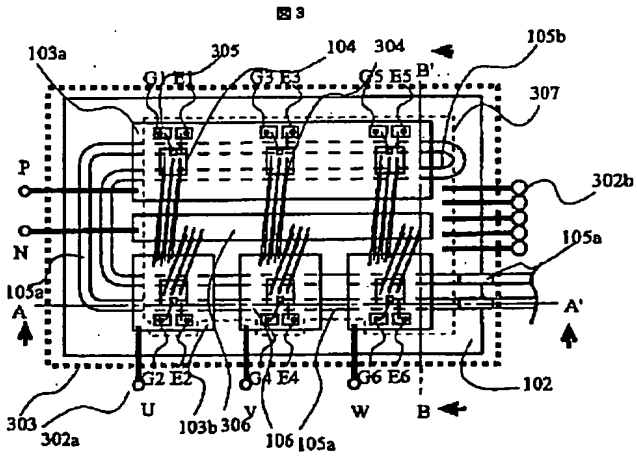

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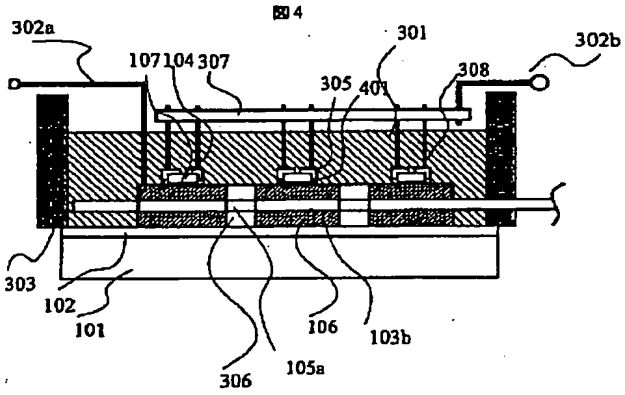

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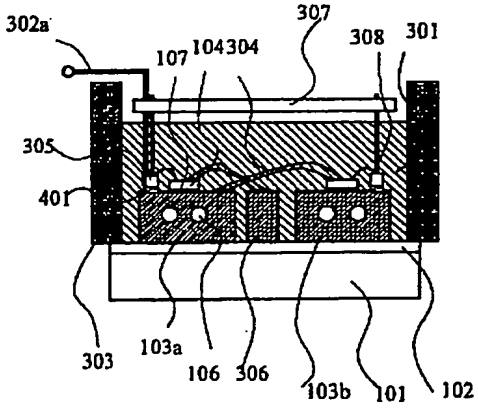

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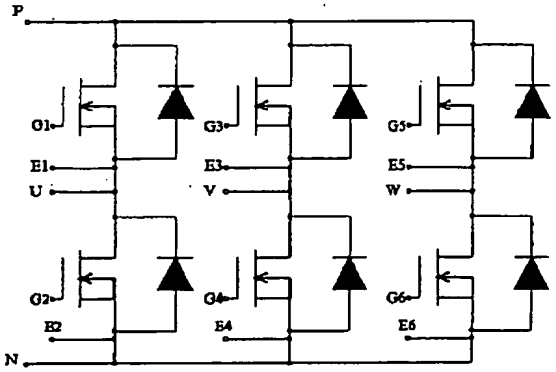

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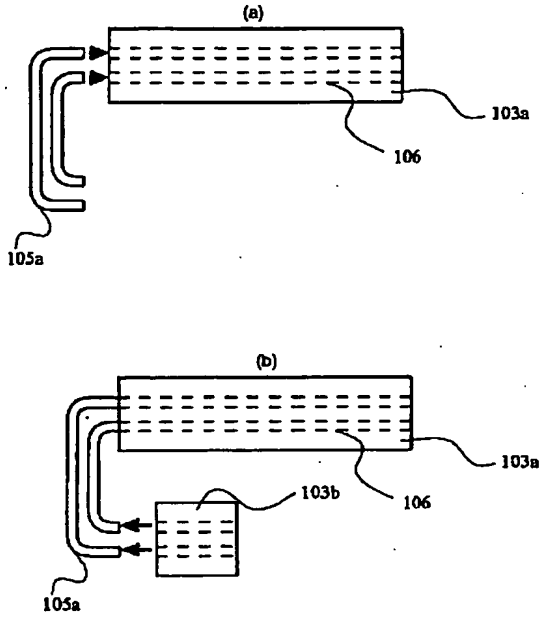

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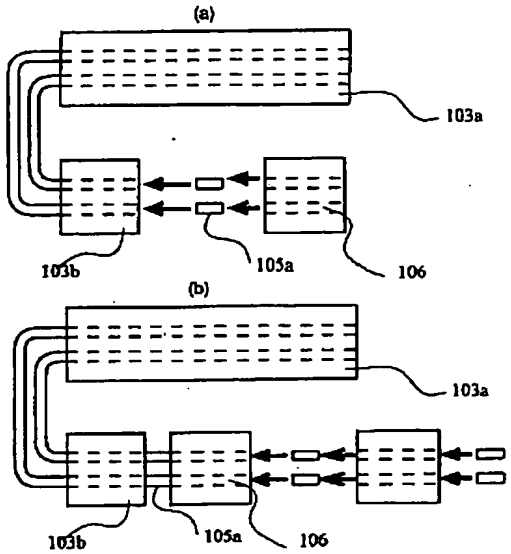

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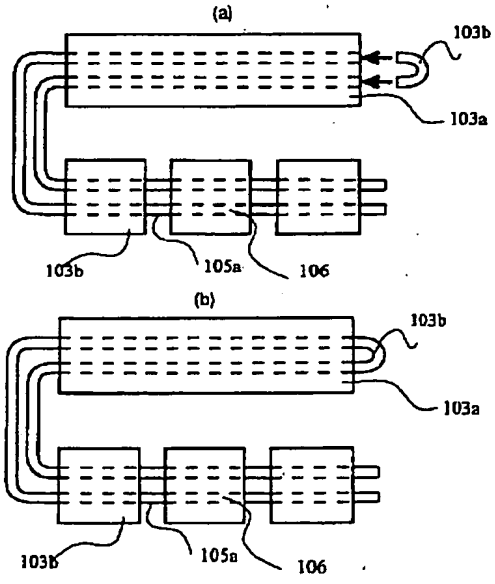

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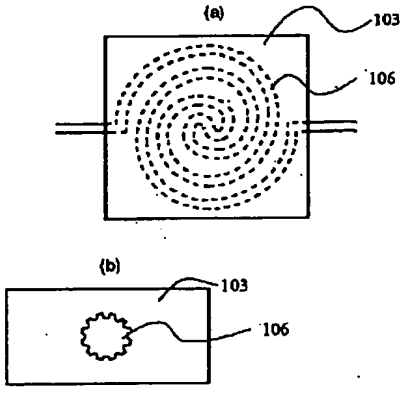
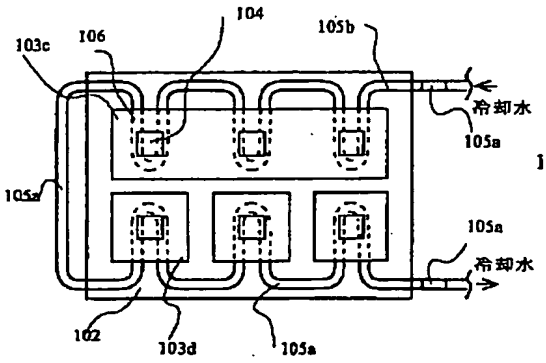
図１０



【図１１】

図１１



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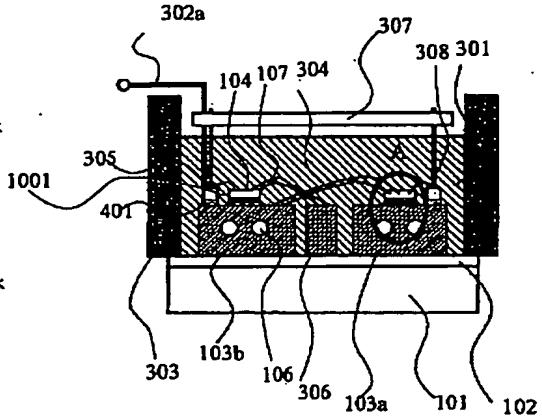

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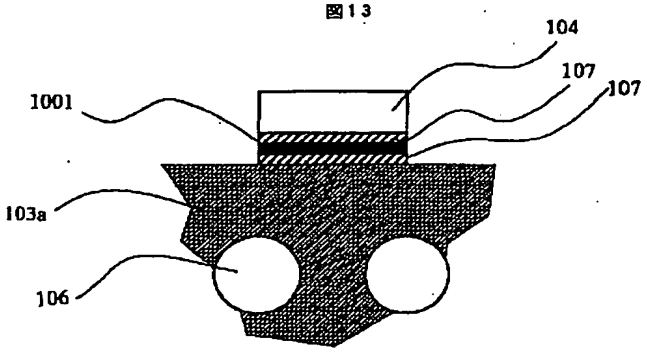

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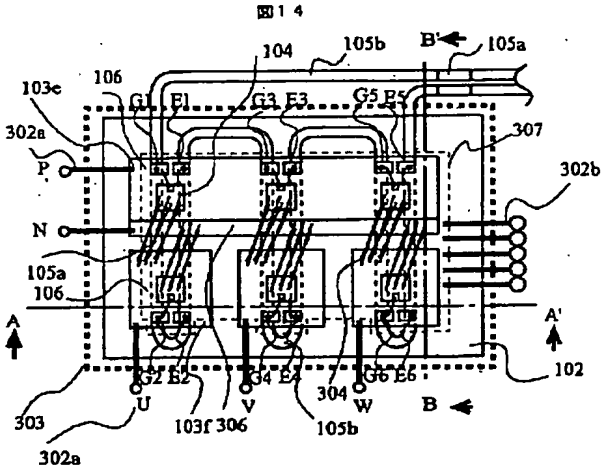
図１４



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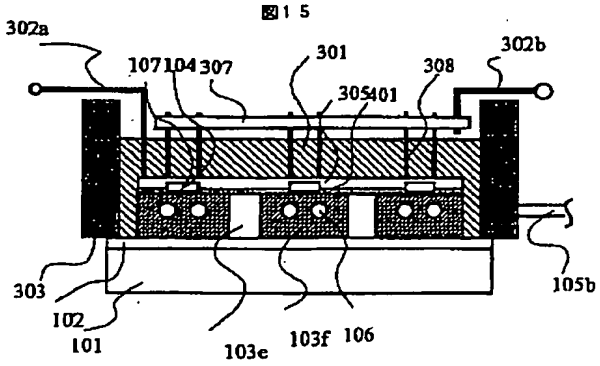

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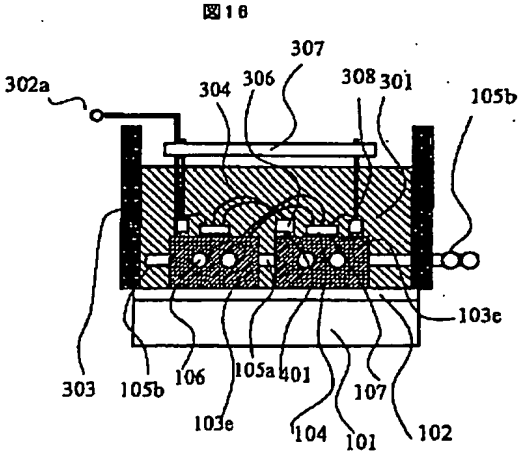

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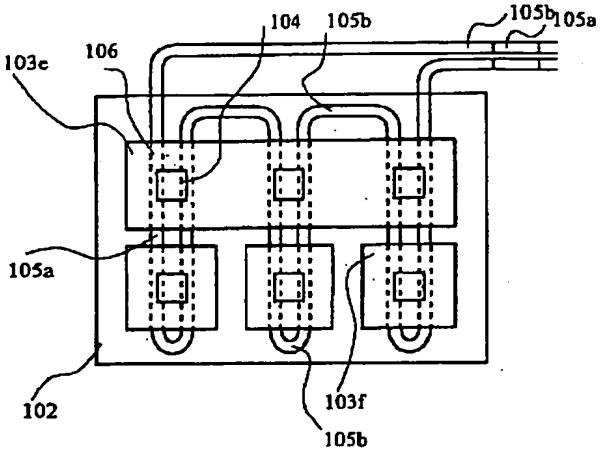

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図１８

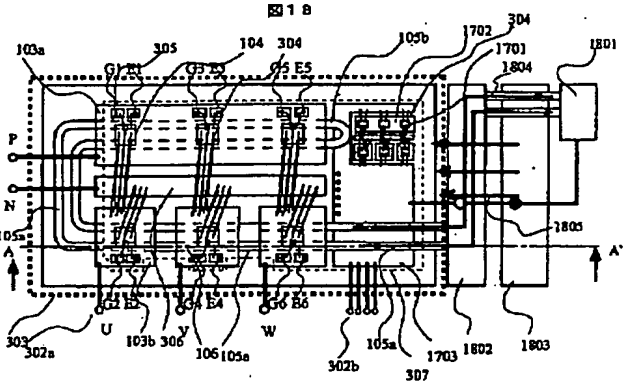

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図１９

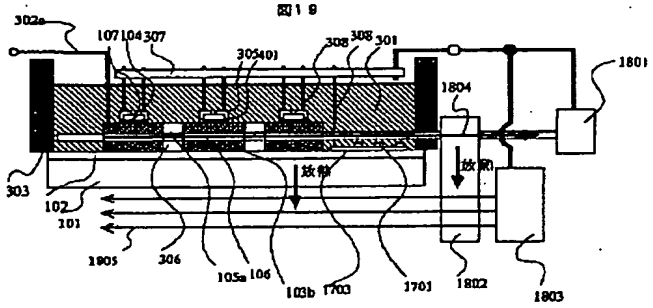

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図２０

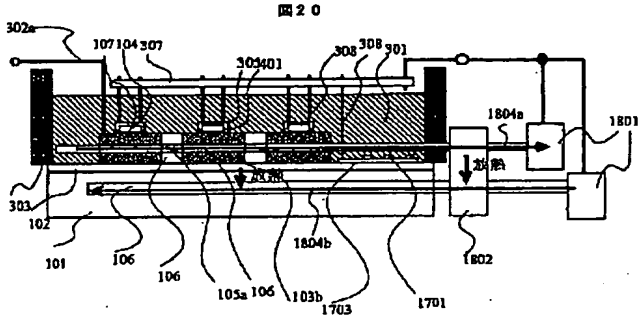

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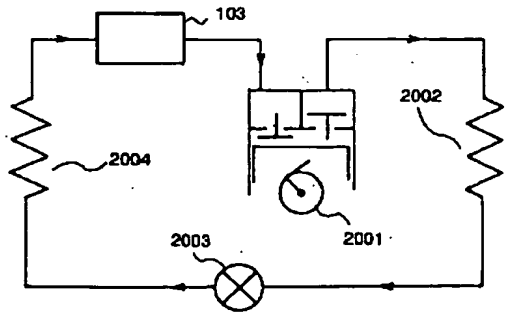
図２１



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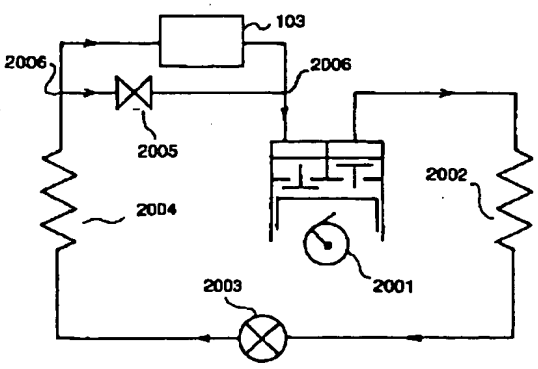

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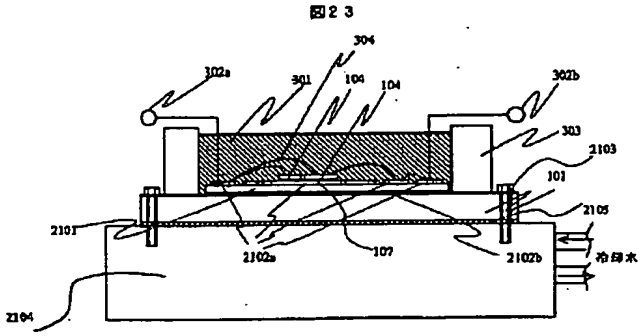

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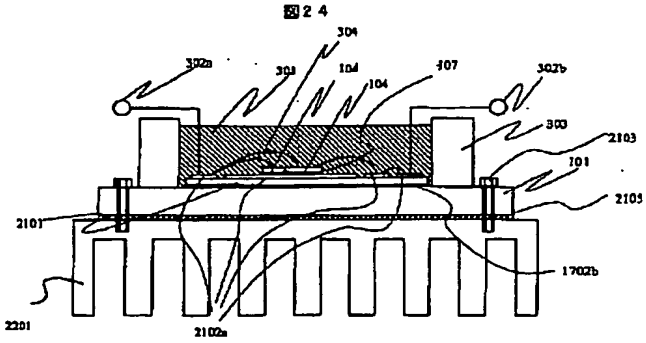

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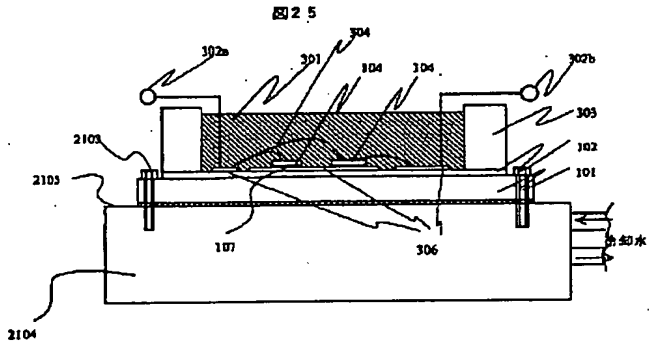

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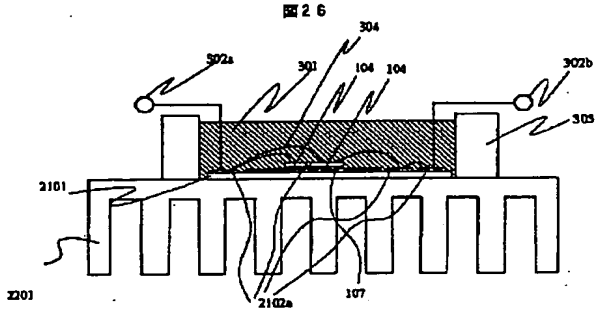

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PA04 PA05
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